PB-217 965

OPERATIONS MANUAL FOR 7.5 MGD WATER RECLAMATION PLANT. SOUTH TAHOE PUBLICITY UTILITY DISTRICT, SOUTH LAKE TAHOE, CALIFORNIA

South Tahoe Public Utility District
South Lake Tahoe, California

September 1967

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

DEAN

PB 217 965

OPERATIONS MANUAL FOR 7.5 MGD WATER RECLAMATION PLANT

SOUTH TAHOE P. U. D.

SEPTEMBER 1967

CORNELL, HOWLAND, HAYES & MERRYFIELD

IN COOPERATION WITH

CLAIR A. HILL & ASSOCIATES

REDDING, CALIFORNIA

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

LIBRARY, NERC-CINCINNATI
ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

OPERATIONS MANUAL
FOR 7.5 MGD
WATER RECLAMATION PLANT

REGISTERED PROFESSIONAL ENGINEER
RUSSEL L. CULP
No. 17,238
CIVIL ENGINEER
STATE OF CALIFORNIA

SOUTH TAHOE PUBLIC UTILITY DISTRICT

South Lake Tahoe, California

September, 1967

In Cooperation with
Clair A. Hill & Associates
Redding, California

Cornell, Howland, Hayes & Merryfield
Engineers and Planners
Corvallis, Oregon

Record No. C3988.7

Copy No. 28

TABLE OF CONTENTS

Description — Page No.

INTRODUCTION 1

- Purpose of Treatment 1

FLOW PATTERNS 1

- Plant Flow 1
- Primary Treatment 3
- Secondary Treatment 5
- Sludge Recirculation Pump Station No. 1 12
- Recirculation Pump Station No. 2 30
- Sludge Flow Division Box 33
- Return Sludge, Control Center 33
- Raw Sludge and Waste Activated Sludge Pumps 39
- Waste Activated Sludge Flotation Thickener 40
- Digesters 49
- Secondary and Final Effluent Pump Stations 49
- Ballast Ponds 56
- Separation Beds 37
- Backwash Water Decanting Tank 37
- Carbon Columns 47
- Ammonia Stripping 47
- Recarbonation 47
- Chemical Application 55
  - Chlorine 55
  - Lime (Splitter Box) 57
  - Polyelectrolyte 59
    - Separation Beds 59
    - Other Points 59
    - Centrifuges 61
  - Alum 62
  - Carbon Dioxide (Flue Gas) 64
- Activated Carbon Treatment C-1
  - Purpose C-1
  - Carbon Transfer C-1
  - Carbon Regeneration C-3
    - Control of Carbon Regeneration C-6
    - Apparent Density Test for Carbon C-6
    - Operation of Carbon Regeneration Furnace C-9
      - Startup C-9
      - Shutdown C-11
      - Malfunctions C-12
    - Carbon De-fining C-12

TABLE OF CONTENTS

Description — Page No.

FLOW PATTERNS (Continued)

- Solids Handling 67
  - Raw and Biological Sludge 67
  - Chemical Sludge 69
    - Alum 69
    - Lime 69
- Emergency Operation 70
  - Electric Power Outage 70
  - Natural Gas Off 71

PROCESS 72

- General 72
- Prechlorination 72
- Screening and Sewage Grinding 73
- Chemical Feed 75
- Primary Sedimentation 77
- Sludge Withdrawal 77
- Secondary Treatment 82
  - General 82
  - Aeration Basins 82
  - Diffused Air Aeration 82
  - Mechanical Aeration 82
  - Return Activated Sludge 82
  - Waste Activated Sludge 84
- Chemical Treatment and Phosphate Removal 86
  - General 86
  - Chemicals 86
  - Rapid Mix 87
  - Flocculation 87
  - Chemical Clarifier 87
  - Recarbonation (Alternate) 87
- Nitrogen Removal 88
  - Ammonia Stripping 88
  - Primary Recarbonation 88
  - Reaction Basin 89
  - Secondary Recarbonation 89
- Filtration 89
  - Chemicals 89
  - Separation Beds 89
  - Backwashing 89
  - Decanting Tank 89
- Carbon Adsorption 90
- Disinfection 90
- Granular Activated Carbon Regeneration 90

TABLE OF CONTENTS

Description — Page No.

PROCESS (Continued)

- Sludge Incineration 93
  - Waste Activated Sludge Thickening 93
  - Primary and Waste Activated Sludge Dewatering 97
  - Burning 98
  - Ash Disposal 98
- Lime Recalcining 98
  - Lime Mud Thickening 98
  - Dewatering Lime Sludge 99
  - Recalcining 100
  - Lime Reuse 101
  - Makeup Lime Use 102

CONTROL OF PLANT OPERATION 104

- Primary Treatment 104
  - Lime Application and pH 104
  - Sludge Withdrawal 105
- Secondary Treatment 105
  - Mixed Liquor Solids 105
  - Load Factor 105
  - Sludge Volume Index (SVI) 105
  - Dissolved Oxygen (D.O.) 105
  - Return Sludge 105
- Chemical Treatment 106
  - Flocculation Basin, pH 106
  - Recarbonation (Alternate) 106
- Ammonia Stripping 106
  - Influent pH 106
  - Air to Water Ratio 106
  - Recarbonation (Two-Stage) 109
- Filtration 109
- Carbon Adsorption 111
- Carbon Regeneration 111
- Sludge Incineration 112
  - Solids Content of Thickened Sludge 112
  - Solids Content of Dewatered Sludge 112
- Lime Recalcining 112
  - Solids Content of Dewatered Sludge 112
  - CaO Content of Recalcined Lime 112

TABLE OF CONTENTS

Description — Page No.

SAMPLING & LABORATORY TESTS — T-1

- Sample Collection — T-1
- Tests for Control of Plant Operation — T-2
  - Settleable Solids — T-2
  - Suspended Solids — T-2
  - Total Solids — T-3
  - Total Volatile Solids — T-3
  - Sludge Volume Index (SVI) — T-3
  - Sewage Solids - Lab Analysis — T-5
  - Sludge Analysis - Lab Work Sheet — T-6
  - Dissolved Oxygen (DO) — T-7
  - Dissolved Oxygen Record — T-9
  - Biochemical Oxygen Demand (BOD) — T-10
  - Load Factor — T-14
  - Microscopic Examination of Activated Sludge — T-14
  - Chemical Oxygen Demand (COD) — T-16
  - COD Analysis — T-18
  - Calcium Analysis — T-19
  - Calcium Concentration Work Sheet — T-20
  - Iodine Number of Activated Carbon — T-21
  - Volatile Acids in Digesting Sludge — T-26
  - Colorimetric Determination of pH — T-27
  - Alkalinity — T-29
  - Colorimetric Measurement of Chlorine Residual — T-30
  - Electronic pH Measurement — T-32
  - Color Measurements (Hellige) — T-32
  - Turbidity Measurements (Hellige) — T-33
  - Specific Conductance — T-33
- Tests for Plant Efficiency & Record Purposes — T-36
  - Total Phosphorus (FWPCA Method) — T-36
  - Orthophosphate (Stannous Chloride Method) — T-36
  - Ammonia Nitrogen (Distillation Method) — T-38
  - Ammonia Nitrogen - Lab Analysis — T-39
  - Organic Nitrogen — T-40
  - Nitrate Nitrogen (Brucine Method) — T-40
  - Nitrate Nitrogen - Lab Analysis — T-42
  - Methylene Blue Active Substance (MBAS) (Short Method) — T-43
  - ABS Analysis Sheet — T-45
  - Data Summary Sheet Form — T-46

LIST OF FIGURES

Figure No.	Title	Page No.
1	Schematic Flow and Process Diagram	2
2	Structure Location and Flow Diagram	4
3	Primary Treatment - Normal Operation	6
4	Primary Treatment - Primary Clarifier No. 1 Out of Service	7
5	Primary Treatment - Primary Clarifier No. 2 Out of Service	8
6	Primary Treatment - Both Primary Clarifiers Out of Service	9
7	Secondary and Chemical Clarifiers - Normal Operation	13
8	Secondary and Chemical Clarifiers - Secondary Clarifier	14
9	Secondary and Chemical Clarifiers - Secondary Clarifier	15
10	Secondary and Chemical Clarifiers - Secondary Clarifier No. 2 Out of Service - Flow Less than 4 MGD	16
11	Secondary and Chemical Clarifiers - Secondary Clarifier No. 2 Out of Service - Flow Greater than 4 MGD	17
12	Secondary and Chemical Clarifiers - Flash Mix, Flocculation Basin, or Chemical Clarifier Out of Service	18
13	Secondary and Chemical Clarifiers - Sludge Withdrawal Pipes	19
14	Sludge Recirculation Pump Station No. 1 - Normal Operation	21
15	Sludge Recirculation Pump Station No. 1 - Secondary Sludge Pump No. 1 Out of Service	22
16	Sludge Recirculation Pump Station No. 1 - Secondary Sludge Pump No. 2 Out of Service	23
17	Sludge Recirculation Pump Station No. 1 - Secondary Sludge Pump No. 3 Out of Service	24
18	Sludge Recirculation Pump Station No. 1 - Backflush Sludge Lines from Sec. Clarifier No. 2 and Chemical Clarifier	25
19	Sludge Recirculation Pump Station No. 1 - Pumping Down Sec. Clarifier No. 2	26
20	Sludge Recirculation Pump Station No. 1 - Pump Down Chemical Clarifier	27
21	Sludge Recirculation Pump Station No. 1 - Pumping Down Flash Mix & Floc Basins	28
22	Sludge Recirculation Pump Station No. 2 - Normal Operation	31

LIST OF FIGURES (Continued)

Figure No.	Title	Page No.
23	Sludge Recirculation Pump Station No. 2 - Sludge Thickener Out of Service	32
24	Sludge Flow Division Box - Normal Operation	34
25	Sludge Flow Division Box - Primary Clarifier No. 1 Out of Service	35
26	Sludge Flow Division Box - Primary Clarifier No. 2 Out of Service	36
27	Sludge Flow Division Box - Flotation Thickener Out of Service	37
28	Return Sludge, Control Center	38
29	Primary Sludge & Waste Activated Sludge Pumps - Normal Operation	41
30	Primary Sludge & Waste Activated Sludge Pumps - Centrifuges Out of Service	42
31	Primary Sludge & Waste Activated Sludge Pumps - Sludge Transfer Pump No. 1 Out of Service	43
32	Primary Sludge & Waste Activated Sludge Pumps - Sludge Transfer Pump No. 2 Out of Service	44
33	Primary Sludge & Waste Activated Sludge Pumps - Sludge Transfer Pump No. 3 Out of Service	45
34	Primary Sludge & Waste Activated Sludge Pumps - Sludge Transfer Pump No. 4 Out of Service	46
35	Primary Sludge & Waste Activated Sludge Pumps - Use of Sludge Transfer Pump No. 2 to Clean Sludge Line from Primary Clarifier No. 2	47
36	Waste Activated Sludge Flotation Thickener	48
37	Secondary and Final Effluent Pump Stations - Normal Operation	51
38	Secondary and Final Effluent Pump Stations - No. 3 Water Supply Line Out of Service	52
39	Secondary and Final Effluent Pump Stations - Final Effluent Pumps Out of Service	53
40	Secondary and Final Effluent Pump Station - Quality of Final Effluent Not Good Enough for Export	54
41	Secondary and Final Effluent Pump Station - Pumping from 60 mg Emergency Storage Pond to Luther Pass	55
42	Ballast Ponds - Normal Operation	57
43	Ballast Ponds - Pond No. 1 Out of Service	58
44	Ballast Ponds - Pond No. 2 Out of Service	59
45	Ballast Ponds - Tertiary Plant Out of Service	60
46	Effleunt and Pond No. 1 Used for Final Effleunt	61
47	Return from Emergency Pond for Tertiary Treatment	62

LIST OF FIGURES

Figure No.	Title	Page No.
48	Separation Beds - Filter Cycle	38
49	Separation Beds - Backwash Cycle	39
50	Separation Beds - Filter to Waste Cycle	40
51	Strainer in Connecting Pipeline Between Filters	41
52	Backwash Water Decanting Tank - Normal Operation with Decant Cycle Timer in Use, Decanted Water to Ballast Ponds, Lime Sludge to Chemical Rapid Mix Basin	43
53	Backwash Water Decanting Tank - Tank Used for Flow Equalization Only - All Backwash Water Flows through Chemical Clarifier, Decant Cycle Timer not Used	44
54	Backwash Water Decanting Tank - Decant Cycle Timer in Use, Alum Sludge to Primary Tank, Decanted Water to Ballast Ponds	45
55	Backwash Water Decanting Tank - Tank Used for Flow Equalization Only, All Backwash Water Flows Through New Primary Tank, Decant Cycle Timer not Used	46
56	Carbon Columns - Normal Upflow Operation	48
57	Carbon Columns - Upflow Through Carbon Column to Waste	49
58	Carbon Columns - Reverse Flow	50
59	Carbon Columns - Bypassing Carbon Columns	51
60	Ammonia Stripping Tower & Recarbonation Basins - Normal Operation	52
61	Ammonia Stripping Tower & Recarbonation Basins - Stripping Tower Only Bypassed, Gravity Flow Through Recarbonation Basins	53
62	Ammonia Stripping Tower & Recarbonation Basins - Tower & Recarbonation Basins both Bypassed	54
63	Points of Chlorine Application	56
64	Lime Application	58
65	Polyelectrolyte (Secondary Flocculant) Feed to Separation Beds	60
66	Alum Application	63
67	Recarbonation Schematic	65
C-1	Section Through Carbon Column	C-2
C-2	Control Schematic for Carbon Slurry Pumps	C-4
C-3	Carbon De-fining Tank	C-5
C-4	Carbon Regeneration System	C-7
C-5	Apparatus for Determining the Apparent Density of Granular Activated Carbon	C-8
68	Solids Handling - Primary & Secondary Sludge	68
69	Solids Handling - Lime Sludge	70

LIST OF FIGURES

Figure No.	Title	Page No.
70	Primary Treatment Barminutor	74
71	Lime Feed Piping and Mud Thickener Overflow Piping to Primary Clarifiers Nos. 1 and 2	76
72	Raw Sludge Pumping	79
73	Sludge Wasting Control Systems	83
74	Polyelectrolyte Feed Pump Settings	95
74a	Process Control Diagram	104a
75	Percent Ammonia Available for Removal by Stripping at 77°F. as a Function of pH	107
76	Phosphate Concentration and pH Versus Lime Dosage	108
T-1	Iodine Correction Curve	T-25
T-2	Specific Conductance Correction Curve	T-34

OPERATIONS MANUAL FOR THE 7.5 MGD WATER RECLAMATION PLANT OF THE SOUTH TAHOE PUBLIC UTILITY DISTRICT

INTRODUCTION

This manual is an operating guide for the use of personnel who operate and maintain the South Tahoe Water Reclamation Plant. The primary purpose of the manual is to explain the functional operation of the plant, to describe its capabilities and limitations, and to suggest procedures for control of the treatment process. The manual is not intended to cover in detail the routine maintenance and repair of various items of equipment, as this information may be obtained from the drawings and instructions supplied by the manufacturers of the equipment installed in the plant.

Purpose of Treatment. For the present time, the minimum goal of treatment is to meet the waste discharge requirements of the Lahontan Regional Water Quality Control Board for Indian Creek Reservoir in Alpine County. It is also desirable that the effluent be of such high quality that no harm would be done in the event of an accidental discharge of plant effluent within the Tahoe Basin due to a pipeline break or some other reason.

Other considerations make it essential to maintain even higher effluent quality in some respects than is now mandatory. Future consideration of in-basin land disposal will undoubtedly require plant scale demonstration over a period of several years of the ability to meet fully and continuously whatever quality standards may be established. It is certain that any such standards will be even higher than those for export and will require nutrient (phosphorus and nitrogen) removal. In addition, public demonstration of the excellent water reclaimed by the plant, might well lead to future sale of this water for reuse, defraying part of the treatment costs. Successful water reclamation and reuse is a key to optimum water resource development in the Tahoe Basin.

OPERATION

Plant Flow. Figure 1 is a schematic flow and process diagram for the 7.5 mgd plant. Although the plant is often referred to as a tertiary treatment plant, indicating three stages of treatment (or something beyond secondary treatment), actually, there are seven major types of treatment provided for the waste water as shown by Figure 1. These major steps are in order: primary (solids separation), secondary (biological), chemical treatment (for turbidity and phosphate removal), nitrogen removal, filtration, carbon adsorption (of organics), and disinfection. The waste water flow through the plant as shown by Figure 1 is a skeleton schematic only to give a general overall picture of the flow pattern. More details are given later in the manual. The lower part of Figure 1 illustrates the handling of organic and biological solids and the methods

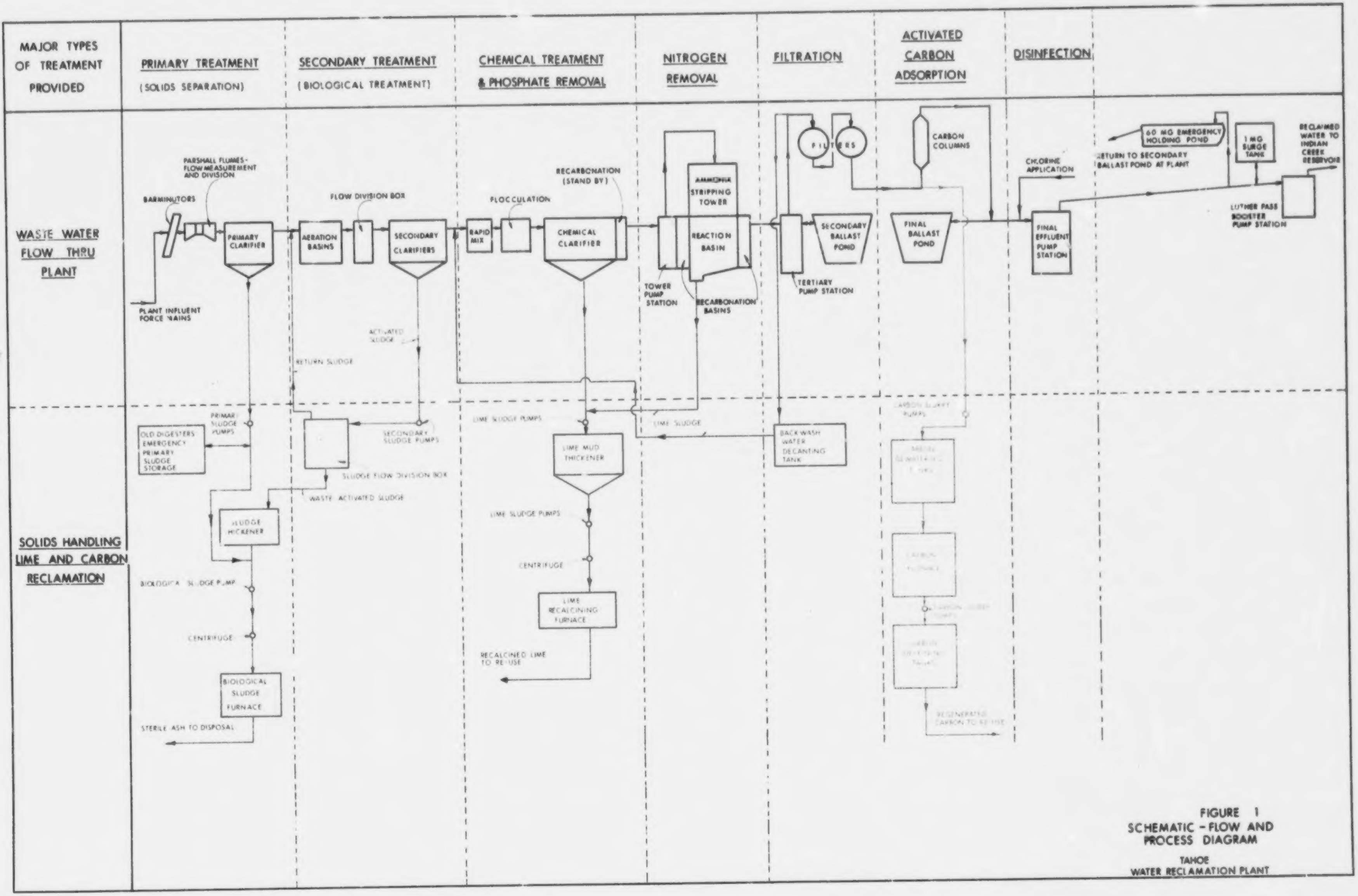


FIGURE 1
SCHEMATIC - FLOW AND PROCESS DIAGRAM
TAHOE
WATER RECLAMATION PLANT

used for reclaiming lime and granular activated carbon. Again, only the major features are shown, and more details of solids and chemical handling are given later.

Figure 2 is also a generalized flow diagram of the entire plant with the plant structures shown in their actual respective locations.

Primary Treatment. The purpose of primary treatment is to separate solids and grease from the waste water. The structures and equipment included in primary treatment are:

1. Rising Well
2. Barminutors
3. Parshall Flumes
4. Primary Clarifier Flow Division Box
5. Primary Clarifiers 1 and 2
6. Sludge and Scum Pumps

These facilities along with the associated piping and valving are shown in Figure 3 which depicts normal operation.

All of the waste water treated at South Tahoe Public Utility District is pumped to the plant by pump stations located at various points around the South Shore. The waste water enters the treatment plant at the rising well. Facilities are provided in the rising well to inject chlorine into the incoming water if a strong odor is present. Adding chlorine for odor control to the incoming or influent waste water is called prechlorination. Experience has shown that pounds per day of chlorine for each mg treated is generally satisfactory for achieving odor control. If a coagulant is needed, there are provisions for feeding alum in the rising well.

The waste water then flows to the barminutors. The purpose of the barminutors is to shred and grind up any solids or rags present. If the blades on the barminutor are dull, rags will not be cut or will be cut in long strips, and the rags could eventually get wound up in a pump. Slide gates can be closed upstream of either barminutor in the event that one of them has to be taken out of service for repairs. A bypass channel with manually cleaned bar screen is available.

Waste water leaving the barminutors enters the Parshall flumes. The purpose of the Parshall flumes is to split the flow in the proper proportion between the two primary clarifiers.

The flow leaving Parshall flume No. 1 passes to the primary clarifier flow division box. The primary clarifier flow division box contains slide gates which make it possible either to bypass the primary treatment facilities or to feed water to the rectangular primary clarifier. In addition, supernatant from the digesters enters the primary clarifier flow division box and is mixed with the influent water.

The waste water leaving the primary clarifier flow division box enters primary clarifier No. 1. The solid materials present in the waste

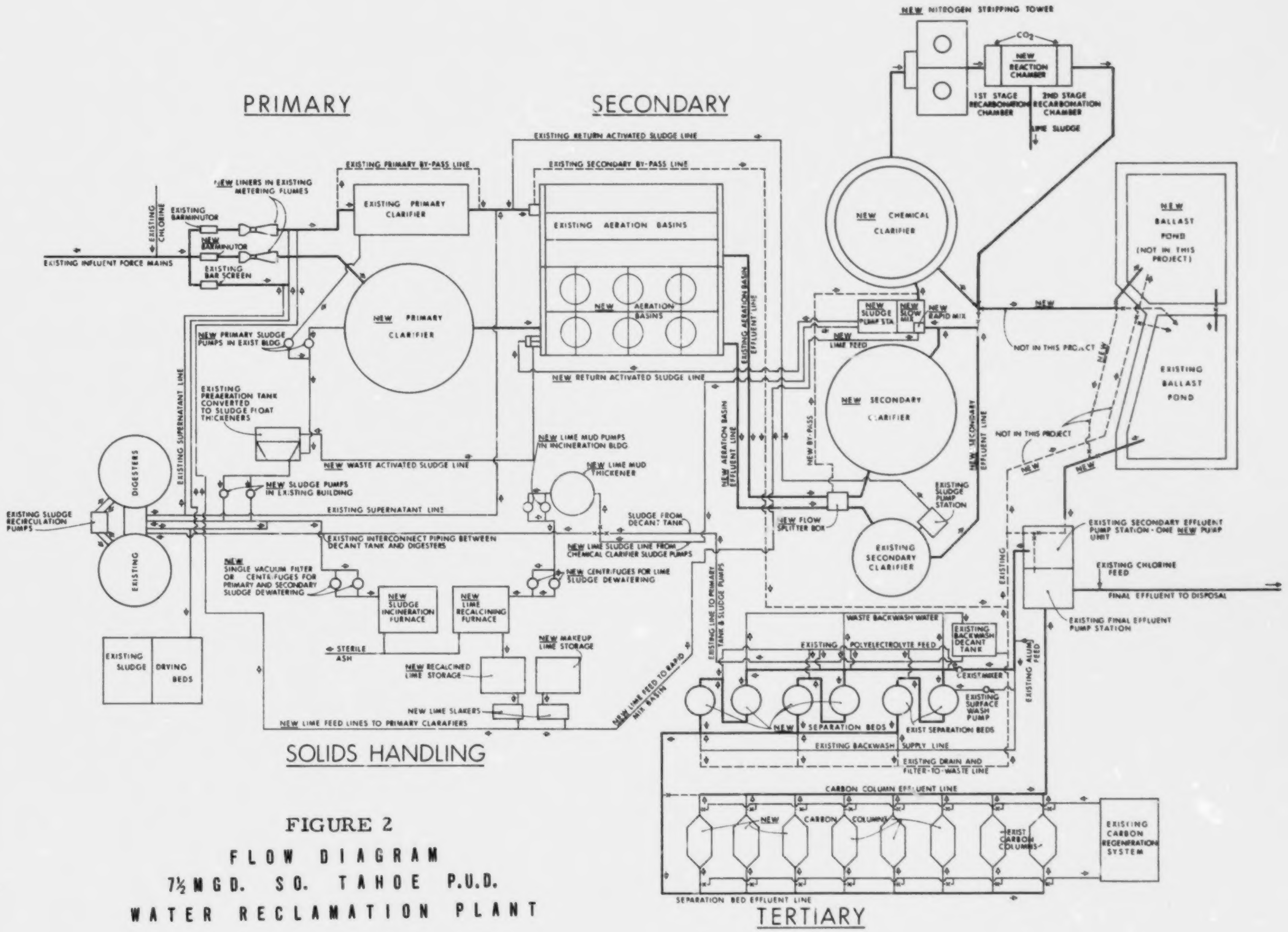

PRIMARY
SECONDARY
SOLIDS HANDLING
TERTIARY
EXISTING INFLUENT FORCE MAINS
EXISTING CHLORINE
EXISTING BARMINUTOR
NEW BARMINUTOR
EXISTING BAR SCREEN
NEW LINERS IN EXISTING METERING FLUMES
EXISTING PRIMARY BY-PASS LINE
EXISTING PRIMARY CLARIFIER
NEW PRIMARY CLARIFIER
NEW PRIMARY SLUDGE PUMPS IN EXIST BLDG
EXISTING PREAERATION TANK CONVERTED TO SLUDGE FLOAT THICKENERS
EXISTING SUPERNATANT LINE
DIGESTERS
EXISTING
EXISTING SLUDGE RECIRCULATION PUMPS
NEW SLUDGE PUMPS IN EXISTING BUILDING
NEW WASTE ACTIVATED SLUDGE LINE
EXISTING SUPERNATANT LINE
EXISTING INTERCONNECT PIPING BETWEEN DECANT TANK AND DIGESTERS
NEW SINGLE VACUUM FILTER OR CENTRIFUGES FOR PRIMARY AND SECONDARY SLUDGE DEWATERING
NEW SLUDGE INCINERATION FURNACE
NEW LIME RECALCINING FURNACE
STERILE ASH
EXISTING SLUDGE DRYING BEDS
NEW RECALCINED LIME STORAGE
NEW MAKEUP LIME STORAGE
NEW LIME SLAKERS
NEW LIME FEED LINES TO PRIMARY CLARAFIERS
NEW LIME FEED TO RAPID MIX BASIN
NEW LIME MUD PUMPS IN INCINERATION BLDG
NEW LIME MUD THICKENER
SLUDGE FROM DECANT TANK
NEW LIME SLUDGE LINE FROM CHEMICAL CLARIFIER SLUDGE PUMPS
NEW CENTRIFUGES FOR LIME SLUDGE DEWATERING
EXISTING RETURN ACTIVATED SLUDGE LINE
EXISTING SECONDARY BY-PASS LINE
EXISTING AERATION BASINS
NEW AERATION BASINS
NEW RETURN ACTIVATED SLUDGE LINE
EXISTING AERATION BASIN EFFLUENT LINE
NEW AERATION BASIN EFFLUENT LINE
NEW BY-PASS
NEW FLOW SPLITTER BOX
NEW SECONDARY CLARIFIER
EXISTING SLUDGE PUMP STATION
EXISTING SECONDARY CLARIFIER
NEW SECONDARY EFFLUENT LINE
NEW LIME FEED
NEW SLUDGE PUMP STA
NEW SLOW MIX
NEW RAPID MIX
NEW CHEMICAL CLARIFIER
NEW NITROGEN STRIPPING TOWER
CO2
NEW REACTION CHAMBER
1ST STAGE RECARBONATION CHAMBER
2ND STAGE RECARBONATION CHAMBER
LIME SLUDGE
NEW
NOT IN THIS PROJECT
NEW BALLAST POND (NOT IN THIS PROJECT)
EXISTING BALLAST POND
NOT IN THIS PROJECT
NEW
NEW
EXISTING SECONDARY EFFLUENT PUMP STATION - ONE NEW PUMP UNIT
EXISTING CHLORINE FEED
FINAL EFFLUENT TO DISPOSAL
EXISTING FINAL EFFLUENT PUMP STATION
EXISTING
EXISTING ALUM FEED
EXISTING LINE TO PRIMARY TANK & SLUDGE PUMPS
WASTE BACKWASH WATER
EXISTING POLYELECTROLYTE FEED
EXISTING BACKWASH DECANT TANK
EXIST MIXER
EXISTING SURFACE WASH PUMP
NEW SEPARATION BEDS
EXIST SEPARATION BEDS
EXISTING BACKWASH SUPPLY LINE
EXISTING DRAIN AND FILTER-TO-WASTE LINE
CARBON COLUMN EFFLUENT LINE
NEW CARBON COLUMNS
EXIST CARBON COLUMNS
EXISTING CARBON REGENERATION SYSTEM
SEPARATION BED EFFLUENT LINE

FIGURE 2

FLOW DIAGRAM

7½ MGD. SO. TAHOE P.U.D.

WATER RECLAMATION PLANT

water settle out in this tank and are pushed to the hopper located at the inlet end of the basin by means of chain-driven plows. The settled solids or sludge is then pumped to the digestors. Grease and other floatable materials, called scum, are pushed to the inlet end of the basin by means of water sprays and removed by a revolving blade. The effluent from the clarifier flows to the aeration basins.

The water leaving Parshall flume No. 2 flows to primary clarifier No. 2. Settled solids are pushed to the center hopper by means of plows. Scum is skimmed from the surface by means of a mechanical arm and is forced into the scum collector box, which then flows to the scum box. The effluent from primary clarifier No. 2 flows to the aeration basins.

Either recalcined or fresh lime may be added to the influent of either or both primary clarifiers. Normally, a dose of about 100 mg/l of recalcined lime would be applied to the water entering each primary clarifier. The pH of the clarifier effluent should not exceed 9.3. Regulation of the lime dosage is discussed in more detail later under Process Control.

The pumps used for pumping primary sludge and scum to the sludge thickener or to the digesters are discussed later.

As previously mentioned, Figure 3 shows the flow pattern and slide gate arrangements for normal operation. If primary clarifier No. 1 has to be taken out of service, Figure 4 shows the flow pattern and the necessary slide gate arrangements. If primary clarifier No. 2 has to be taken out of service, Figure 5 shows the flow pattern and the necessary slide gate positions. If both primary clarifiers have to be removed from service, Figure 6 shows the flow pattern and the necessary slide gate positions.

Secondary Treatment. The purpose of secondary treatment is to satisfy the biological oxygen demand of the waste water. This treatment is accomplished in aeration tanks, where bacteria and protozoans remove over 90 percent of the odor producing materials present in effluent from primary treatment. The structures included in secondary treatment are:

1. Aeration Basins 1, 2, 3, 4, and 5
2. Aeration Devices (Diffusers or Beaters)
3. Secondary Clarifier Flow Division Box
4. Secondary Clarifiers Nos. 1 and 2
5. Sludge Recirculation Pump Stations 1 and 2
6. Sludge Flow Division Box

Figure 7 shows the aeration basins, sludge flow division box, and the associated piping. The flow pattern shown is that under normal operations.

Aeration Basins 1, 2, and 3. Effluent from primary clarifier No. 1 enters aeration basins 1, 2, and 3. Before entering the basins, return sludge from the sludge flow division box is mixed with the incoming water. This return sludge is added in order to accelerate biological action in the aeration tanks.

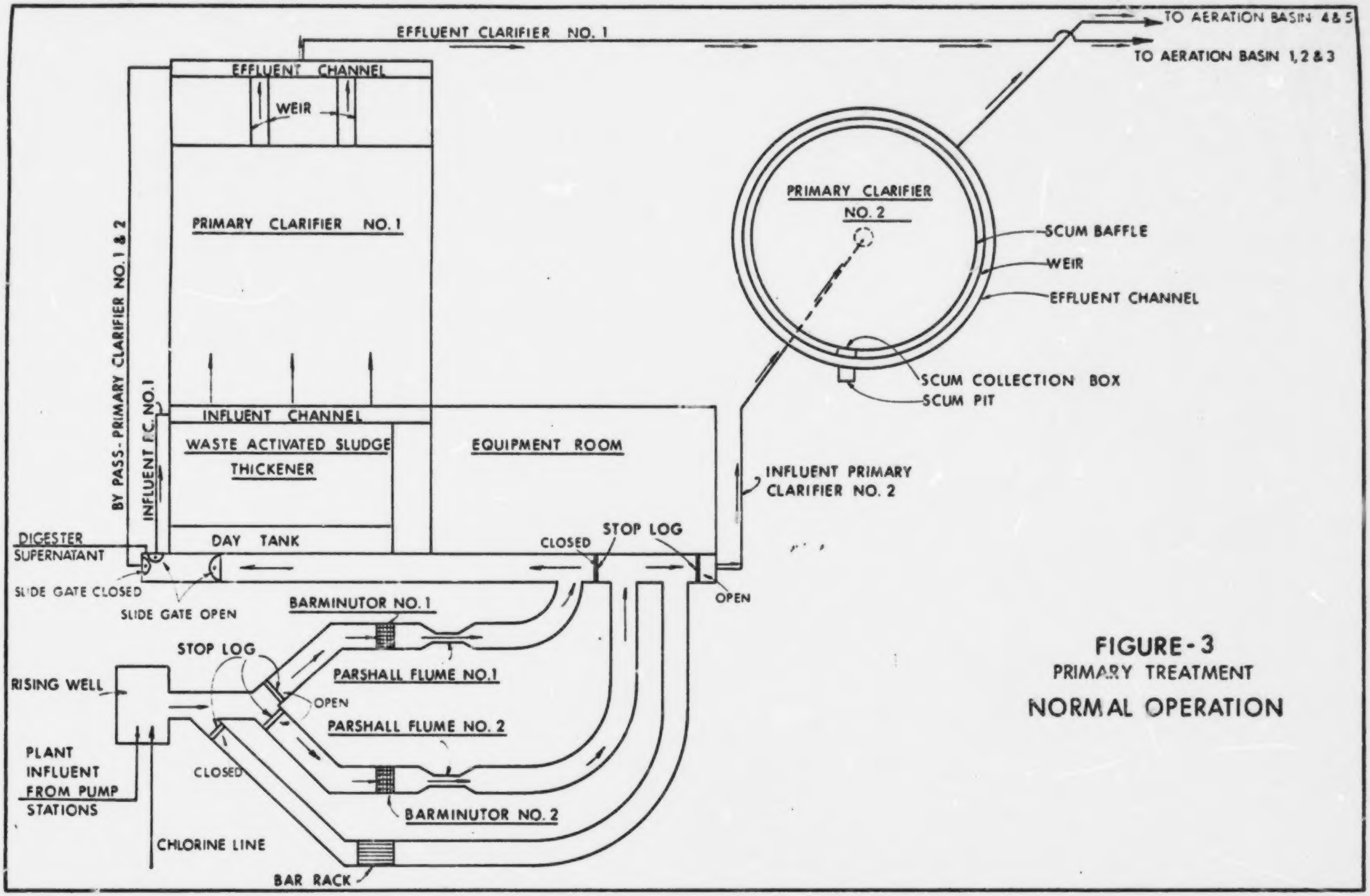


FIGURE - 3
PRIMARY TREATMENT
NORMAL OPERATION

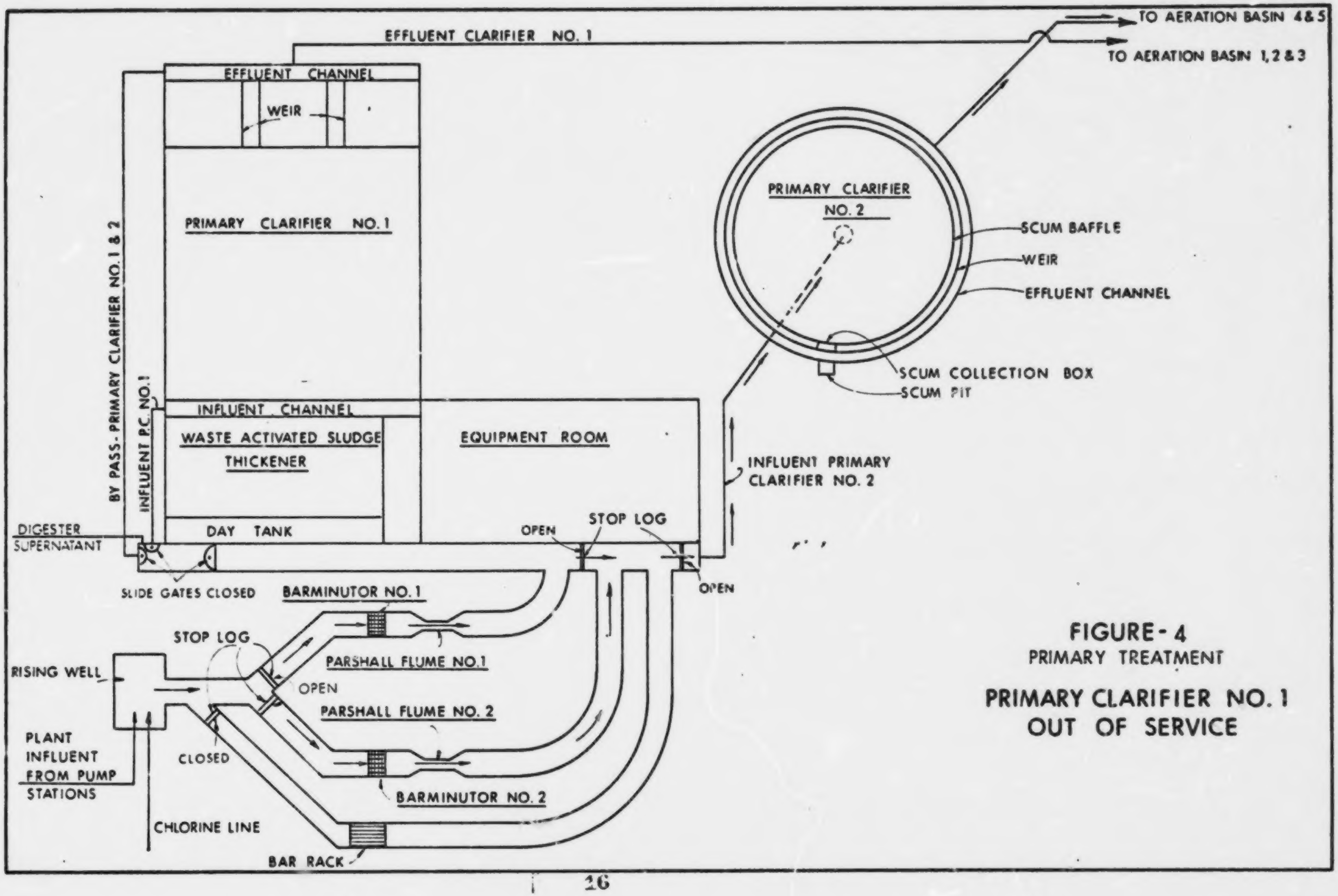


FIGURE-4
PRIMARY TREATMENT

PRIMARY CLARIFIER NO. 1
OUT OF SERVICE

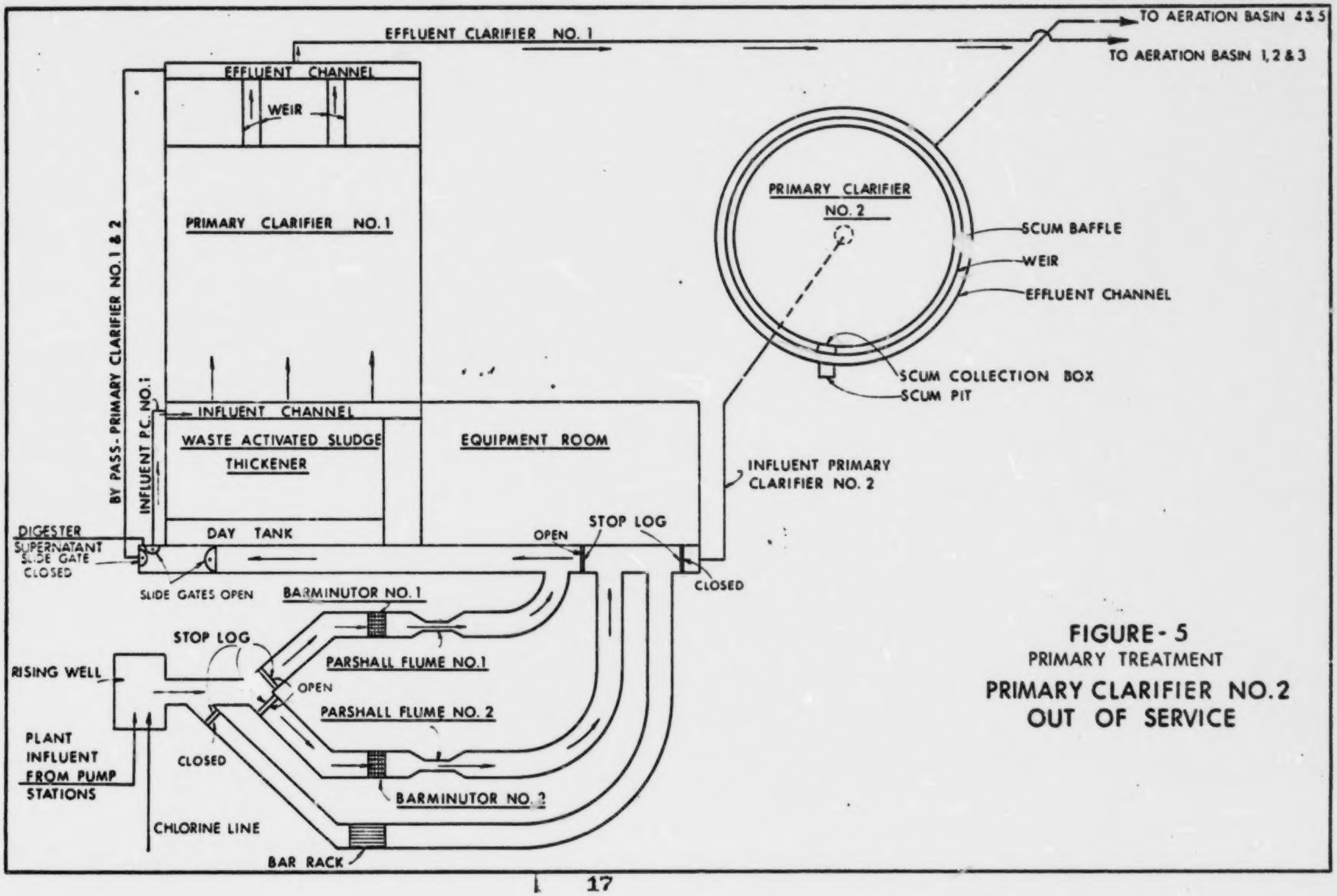


FIGURE - 5
PRIMARY TREATMENT
PRIMARY CLARIFIER NO. 2
OUT OF SERVICE

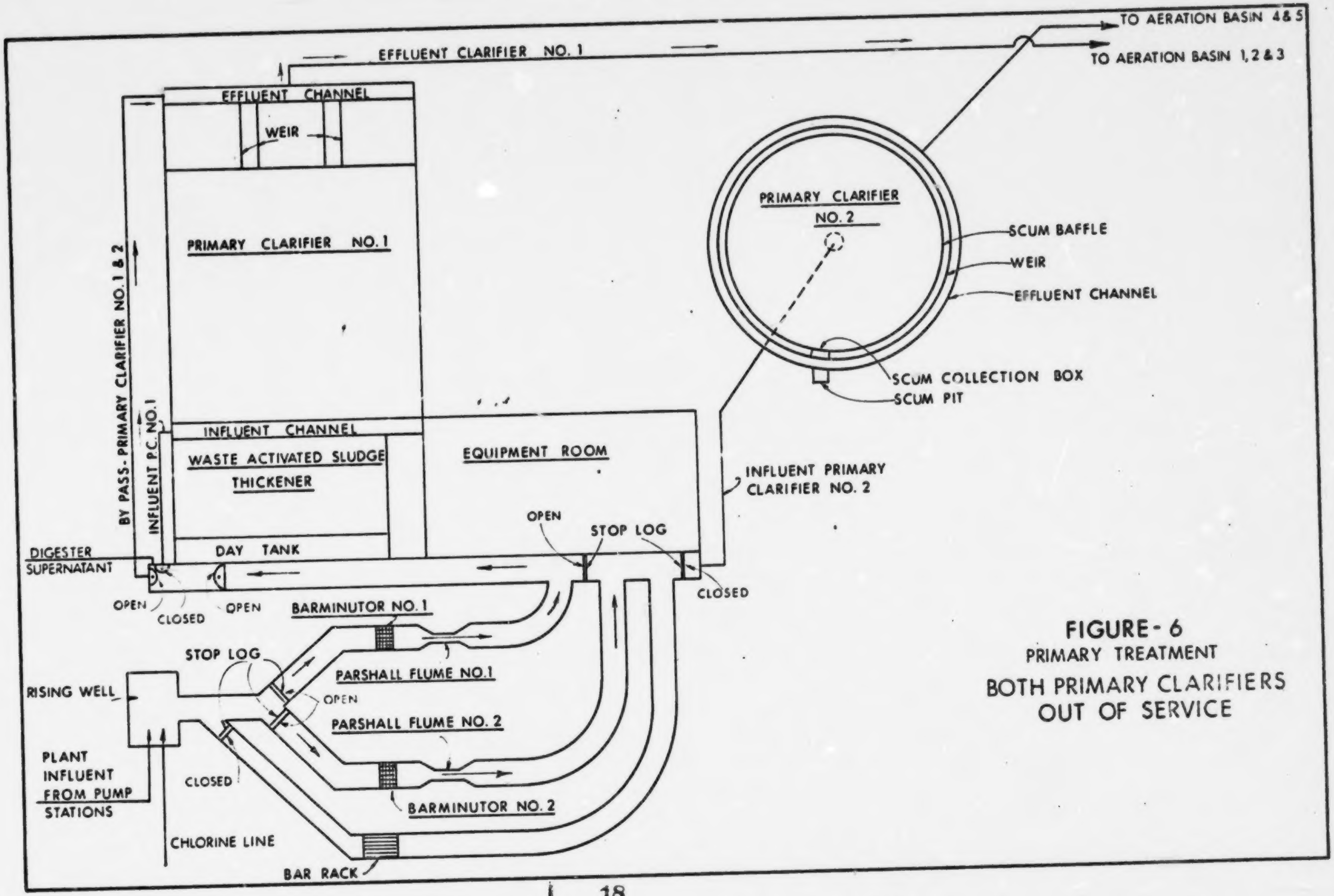


FIGURE - 6
PRIMARY TREATMENT
BOTH PRIMARY CLARIFIERS
OUT OF SERVICE

The resulting mixture then is split into three equal volumes and flows into the three aeration basins. Air is added to the waste water by means of diffusers located at the bottom of the basins. Air is supplied to diffusers by means of blowers located in the Operations Building. Oxygen in the air dissolves in the water and then is used by bacteria in stabilizing or oxidizing the organic materials present.

The waste water remains in the aeration basins from six to eight hours and then flows to the secondary clarifier flow division box.

Aeration Basins 4 and 5. Effluent from primary clarifier No. 2 flows to aeration basins 4 and 5. Before entering the basins, return sludge from the sludge flow division box is mixed with the waste water.

The resulting mixture flows into the pipe headers located on the bottom of the basins. The flow from each of these pipelines is directed towards each of the aerators located in these basins. The flow is split equally to each aerator by means of orifice plates at each point of discharge.

The aeration devices located in these basins are called mechanical aerators or beaters. Air is transferred to the water by the stirring action of blades attached to the rotating shaft. Additional air is supplied through diffusers located at the base of the mechanical aerators.

The effluent from these basins leaves by overflowing weirs located at three points along the length of each basin. The aerated water flows into the effluent channel. It then travels to the secondary clarifier flow division box.

The effluent from aeration basins 1, 2, 3, 4, and 5 then flows to the secondary clarifier flow division box. Figure 7 shows the gate openings and flow pattern for normal operation.

The mixed liquor enters the center portion of the secondary clarifier flow division box and flows over the weir. The position of the stop logs is important, because their location determines the quantity of flow directed to each of the secondary clarifiers. See information which follows on Activated Sludge Process.

The influent to secondary clarifier No. 1 enters this basin at the center well. Activated sludge solids settle to the bottom of the tank and are removed by means of rotating arm containing holes. Pumps in sludge recirculation pump station No. 2 draw suction on this arm and as a result remove the settled activated sludge solids. The details on sludge recirculation pump station No. 2 are discussed later. It is important that this rotating arm be back flushed every other day in order to prevent plugging of any opening.

The effluent from secondary clarifier No. 1 flows over the weir and out to the flash mix basin.

The influent to secondary clarifier No. 2 enters the basin through openings in the center column of the clarifier mechanism. Effluent from the clarifier flows over the outlet weir and is mixed with the effluent from secondary clarifier No. 1, and the two flows then travel together to the flash mix basin.

Activated sludge solids settle to the bottom and are removed from the basin by two methods:

1. The clarifier arms are equipped with suction pipes which collect the sludge as quickly as it settles. The rate at which settled sludge is removed from any location in the basin can be regulated by varying the number of rings located on each pipe in the center well. Figure 13 shows the location of the suction pipes in relation to the clarifier bottom slab and the adjustable rings. The flow through each pipe will vary because of the manner in which the basin is constructed. In general, the maximum rate of sludge removal will be through the pipes located near the center of the clarifier. The minimum rate of sludge removal will be through the pipes located near the outside weir of the clarifier.

The ring settings on the pipe are normally set by visual observation of the sludge being removed. If if is observed that sludge with a low solids content is being removed, then the flow from that particular pipe should be reduced by adding a ring. On the other hand, if the sludge blanket is moving away from the center towards the outlet weir, then the flow should be increased through the pipes removing sludge (not relatively clear liquid) by removing rings.

The sludge removed by these pipes flows through a 16-inch pipe to sludge sump No. 1 located in sludge recirculation pump station No. 1. The details are shown on Figure 14.

2. There will be some settled sludge in the basin which will not be removed by the suction pipes. This sludge is pushed to the center hopper by plows located on the rotating clarifier mechanism. The sludge is removed from the center hopper by pumps located in sludge recirculation pump station No. 1. See Figure 14. Effluent from secondary clarifier No. 2 flows over the weir and is mixed with the effluent from secondary clarifier No. 1. The two flows then travel together to the flash mix basin, which is the point where chemical treatment begins.

Briefly, effluent from the secondary clarifiers flow through the flash mix and flocculation basins, where chemicals are added, mixed, and stirred with the secondary effluent. The secondary effluent and resulting chemical sludge flows to the chemical clarifier. The chemical sludge settles and is removed by a collector mechanism which is identical to the unit in secondary clarifier No. 2. The effluent from the chemical clarifier flows over the weir and out to the pond splitter box. Details of the pond splitter box are shown on Figure 42. Chemical sludge removed by the suction pipes on the clarifier mechanism flows to sludge sump No. 2 in sludge recirculation pump station No. 1. Chemical sludge moved to the center hopper is removed by pumps in the sludge recirculation pump station No. 1.

Alternate Flow Patterns. As previously mentioned, Figure 7 represents the flow pattern under normal operation. However, it will be necessary at times to bypass one of the clarifiers in order to perform routine maintenance or repairs. It is important that the clarifier mechanisms receive their routine maintenance as scheduled in order to avoid major equipment failures.

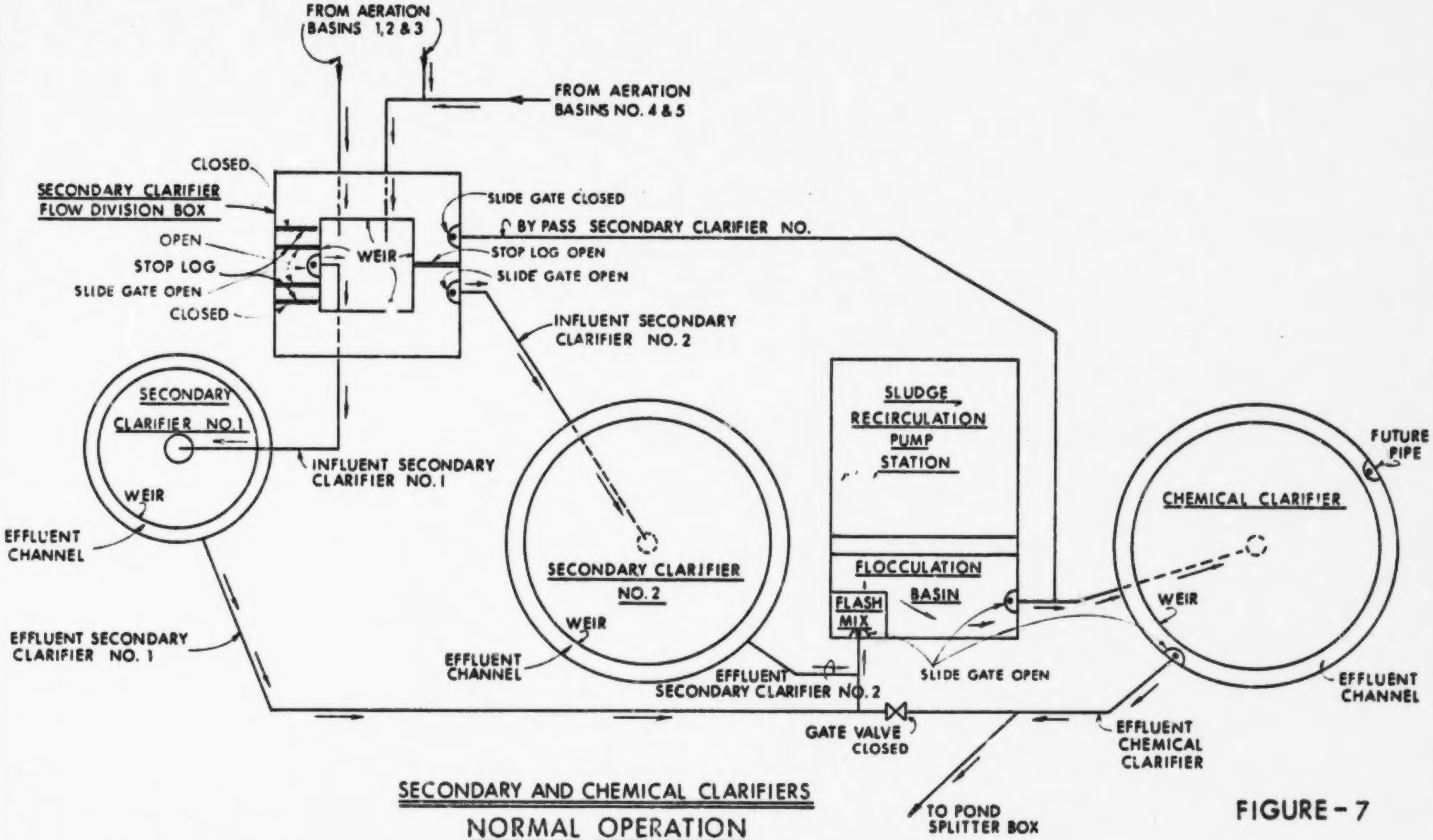
It should be noted that the sole purpose of the chemical clarifier is to operate as a chemical clarifier, as successful operation of the tertiary plant is dependent upon this clarifier. Maintenance schedules should be arranged so that chemical clarifier can operate on chemicals most of the time. This means that secondary clarifier No. 2 should not be taken out of service during the summer except for an equipment failure.

The following figures show the valve settings and flow patterns for several possible flow patterns for the three clarifiers:

Figure	Type of Operation
7	Normal Operation
8	Secondary Clarifier No. 1 Out of Service. Plant Flow Less than 5 mgd
9	Secondary Clarifier No. 1 Out of Service. Plant Flow Greater than 5 mgd.
10	Secondary Clarifier No. 2 Out of Service. Plant Flow Less than 4 mgd.
11	Secondary Clarifier No. 2 Out of Service. Plant Flow Greater than 4 mgd.
12	Chemical Clarifier, Flash Mix or Flocculation Basins, Out of Service.

Sludge Recirculation Pump Station No. 1. The purpose of sludge recirculation pump station No. 1 is to remove settled activated sludge from secondary clarifier No. 2 and settled chemical sludge from the chemical clarifier. This is accomplished by secondary sludge pumps 1, 2, 3, 4, and 5 located in this building. Other equipment located in this building includes:

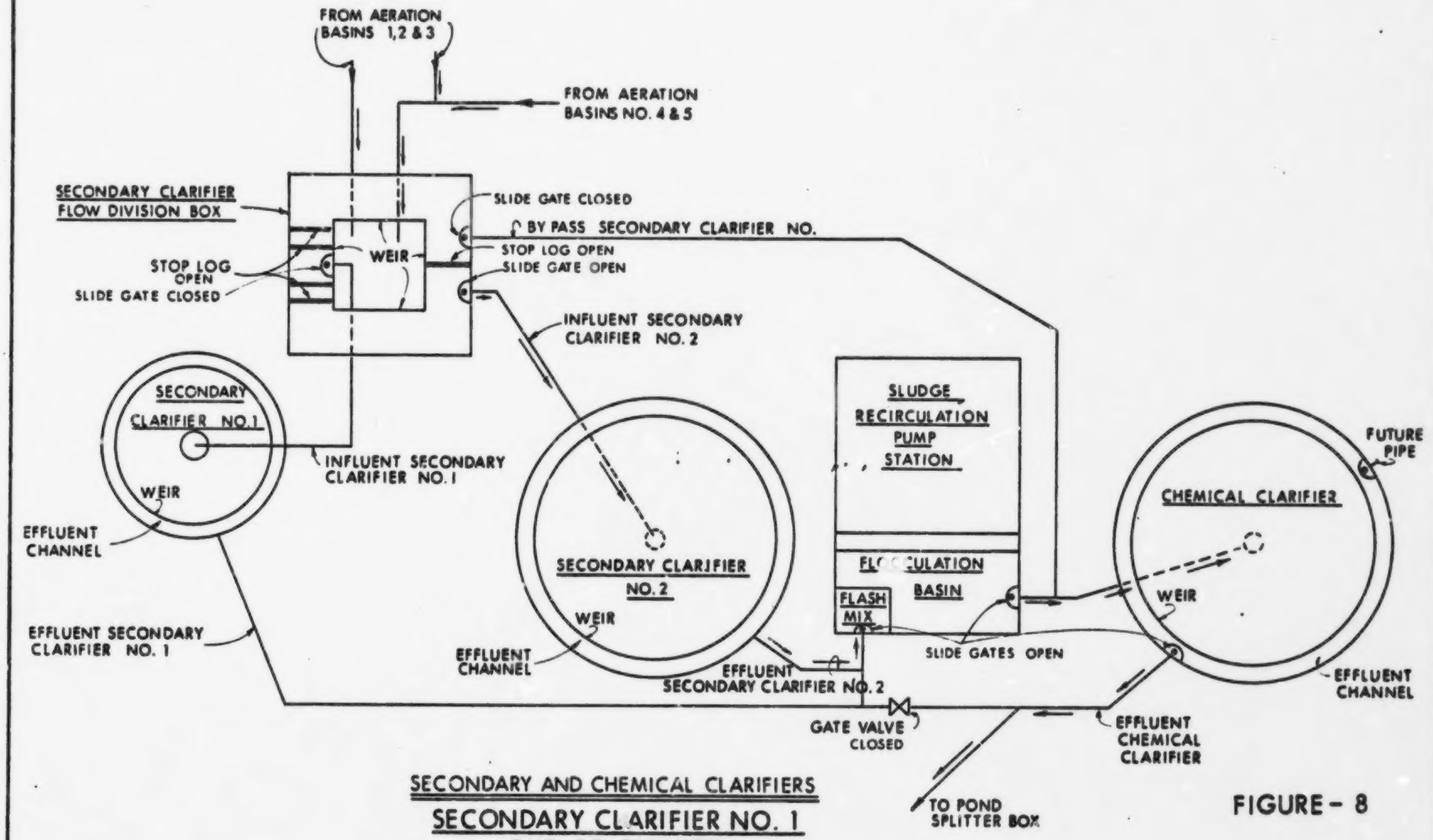
1. Flash Mix Basin
2. Flocculation Basin
3. Sludge Sump No. 1 and 2
4. High and Low Level Alarms in Sludge Sump No. 1 and 2
5. Sludge Density Meter
6. Sludge Density Amplifier


FROM AERATION BASINS 1,2 & 3
FROM AERATION BASINS NO. 4 & 5
CLOSED
SECONDARY CLARIFIER FLOW DIVISION BOX
OPEN
STOP LOG
SLIDE GATE OPEN
CLOSED
WEIR
SLIDE GATE CLOSED
BY PASS SECONDARY CLARIFIER NO.
STOP LOG OPEN
SLIDE GATE OPEN
INFLUENT SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO. 1
INFLUENT SECONDARY CLARIFIER NO. 1
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 2
SLUDGE RECIRCULATION PUMP STATION
FLOCCULATION BASIN
FLASH MIX
SLIDE GATE OPEN
GATE VALVE CLOSED
TO POND SPLITTER BOX
CHEMICAL CLARIFIER
FUTURE PIPE
WEIR
EFFLUENT CHANNEL
EFFLUENT CHEMICAL CLARIFIER

SECONDARY AND CHEMICAL CLARIFIERS

NORMAL OPERATION

FIGURE - 7


FROM AERATION BASINS 1,2 & 3
FROM AERATION BASINS NO. 4 & 5
SECONDARY CLARIFIER FLOW DIVISION BOX
WEIR
STOP LOG OPEN
SLIDE GATE CLOSED
SLIDE GATE CLOSED
BY PASS SECONDARY CLARIFIER NO.
STOP LOG OPEN
SLIDE GATE OPEN
INFLUENT SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO. 1
WEIR
INFLUENT SECONDARY CLARIFIER NO. 1
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 2
SLUDGE RECIRCULATION PUMP STATION
FLOCCULATION BASIN
FLASH MIX
SLIDE GATES OPEN
GATE VALVE CLOSED
TO POND SPLITTER BOX
CHEMICAL CLARIFIER
FUTURE PIPE
WEIR
EFFLUENT CHANNEL
EFFLUENT CHEMICAL CLARIFIER

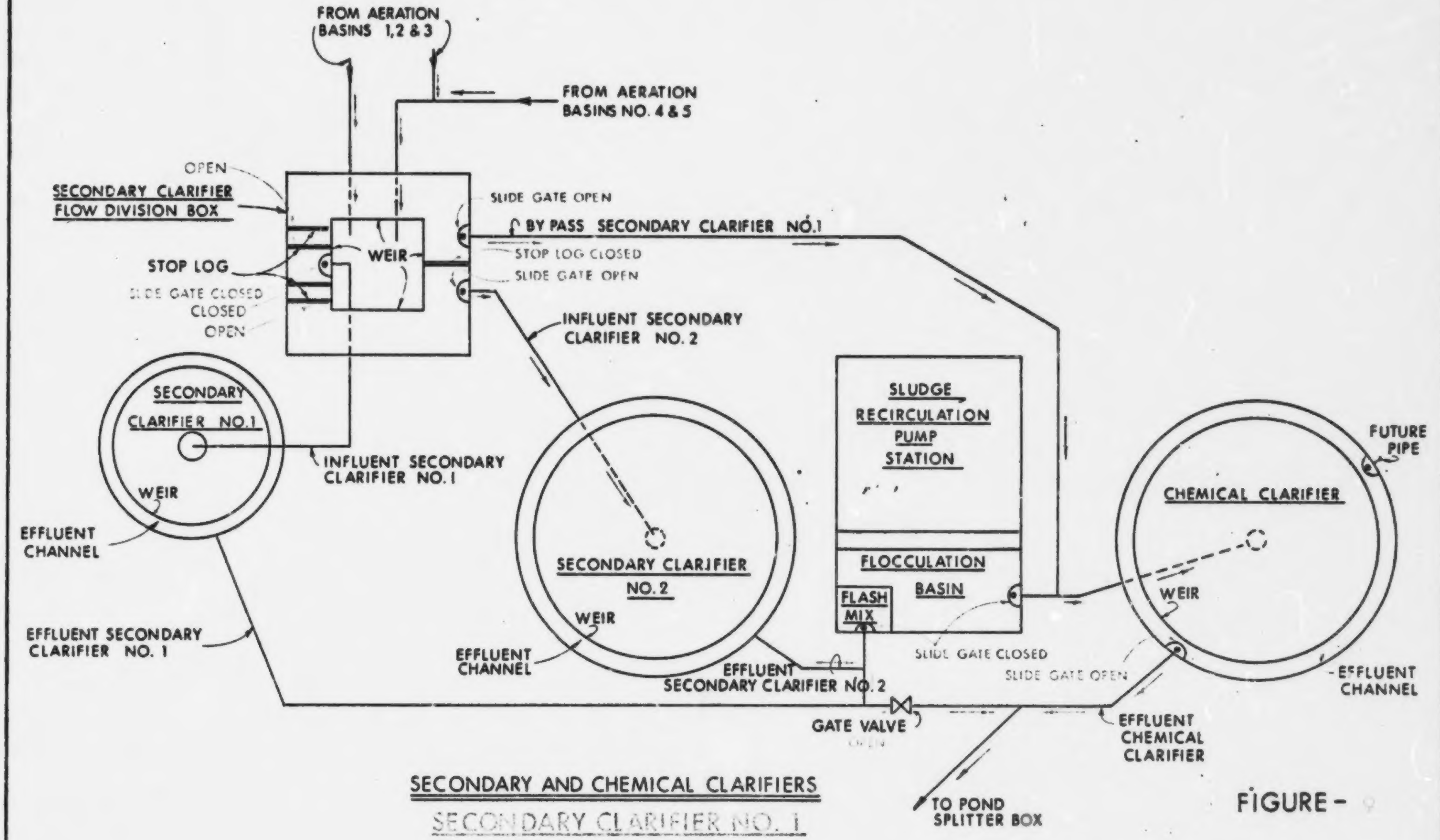
SECONDARY AND CHEMICAL CLARIFIERS

SECONDARY CLARIFIER NO. 1

OUT OF SERVICE

PLANT FLOW LESS THAN 5 M.G.D.

FIGURE - 8

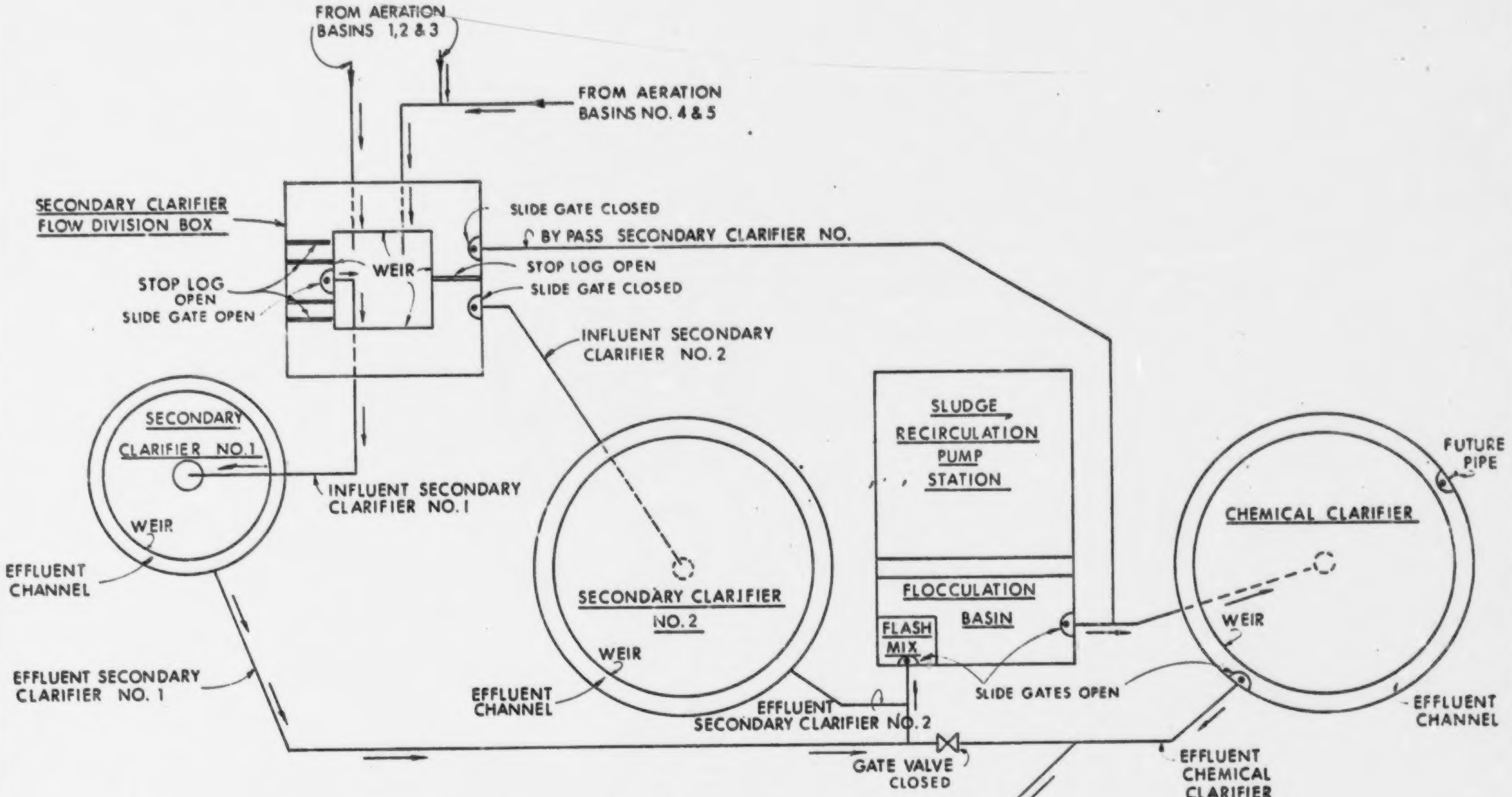

FROM AERATION BASINS 1,2 & 3
FROM AERATION BASINS NO. 4 & 5
OPEN
SECONDARY CLARIFIER FLOW DIVISION BOX
SLIDE GATE OPEN
BY PASS SECONDARY CLARIFIER NO.1
STOP LOG
WEIR
STOP LOG CLOSED
SLIDE GATE OPEN
SLIDE GATE CLOSED
CLOSED
OPEN
INFLUENT SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO.1
INFLUENT SECONDARY CLARIFIER NO. 1
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 2
SLUDGE RECIRCULATION PUMP STATION
FLOCCULATION BASIN
FLASH MIX
GATE VALVE
OPEN
SLIDE GATE CLOSED
SLIDE GATE OPEN
TO POND SPLITTER BOX
CHEMICAL CLARIFIER
FUTURE PIPE
WEIR
EFFLUENT CHANNEL
EFFLUENT CHEMICAL CLARIFIER

SECONDARY AND CHEMICAL CLARIFIERS

SECONDARY CLARIFIER NO. 1 OUT OF SERVICE

PLANT FLOW GREATER THAN 5 M.G.D.

FIGURE - 9


FROM AERATION BASINS 1,2 & 3
FROM AERATION BASINS NO. 4 & 5
SECONDARY CLARIFIER FLOW DIVISION BOX
STOP LOG OPEN
SLIDE GATE OPEN
WEIR
SLIDE GATE CLOSED
BY PASS SECONDARY CLARIFIER NO.
STOP LOG OPEN
SLIDE GATE CLOSED
INFLUENT SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO. 1
INFLUENT SECONDARY CLARIFIER NO. 1
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 2
SLUDGE RECIRCULATION PUMP STATION
FLOCCULATION BASIN
FLASH MIX
SLIDE GATES OPEN
GATE VALVE CLOSED
TO POND SPLITTER BOX
CHEMICAL CLARIFIER
FUTURE PIPE
WEIR
EFFLUENT CHANNEL
EFFLUENT CHEMICAL CLARIFIER

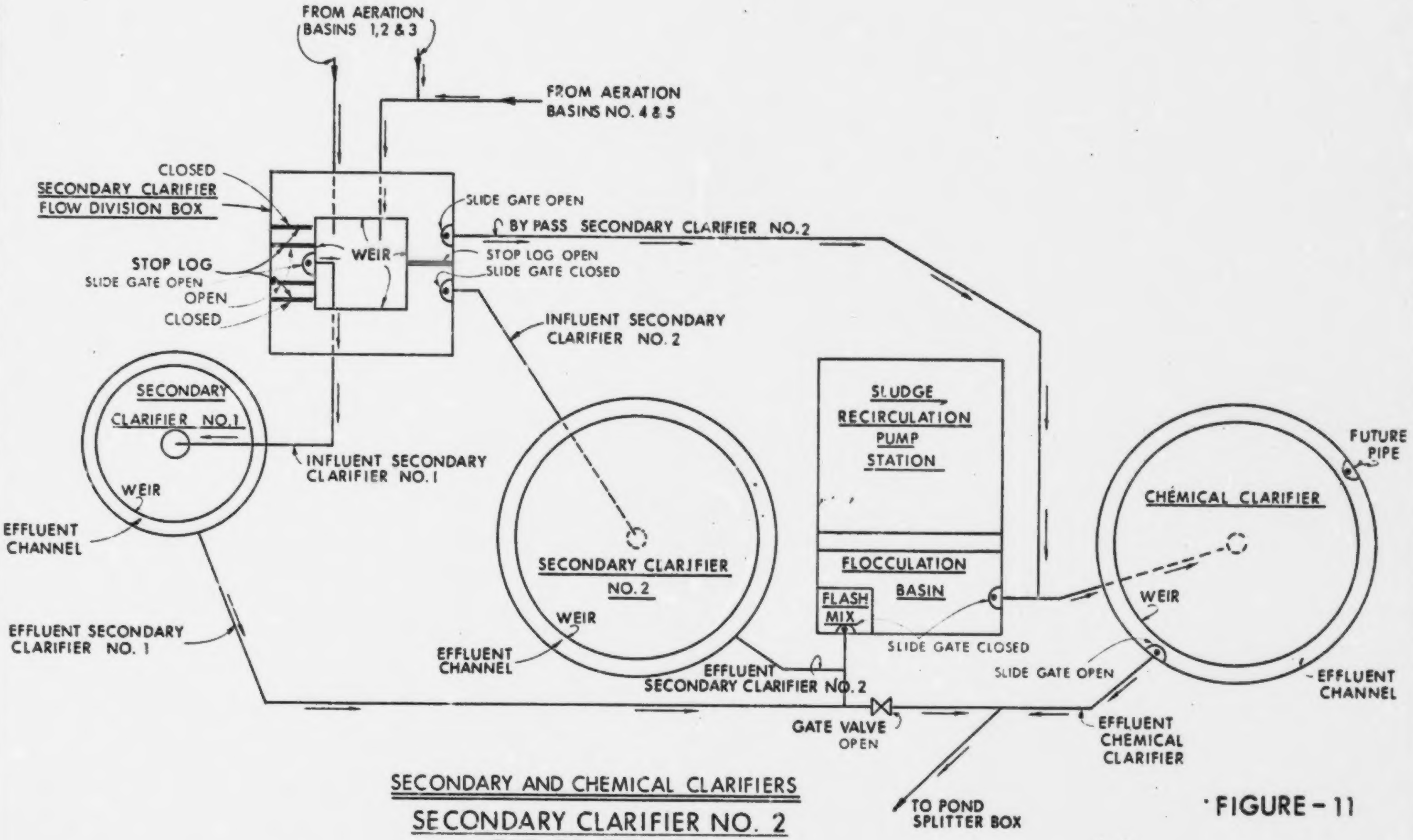
SECONDARY AND CHEMICAL CLARIFIERS

SECONDARY CLARIFIER NO. 2

OUT OF SERVICE

PLANT FLOW LESS THAN 4 M.G.D.

FIGURE - 10


FROM AERATION BASINS 1,2 & 3
FROM AERATION BASINS NO. 4 & 5
CLOSED
SECONDARY CLARIFIER FLOW DIVISION BOX
STOP LOG
SLIDE GATE OPEN
OPEN
CLOSED
WEIR
SLIDE GATE OPEN
BY PASS SECONDARY CLARIFIER NO. 2
STOP LOG OPEN
SLIDE GATE CLOSED
INFLUENT SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO. 1
INFLUENT SECONDARY CLARIFIER NO. 1
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 2
SLUDGE RECIRCULATION PUMP STATION
FLOCCULATION BASIN
FLASH MIX
SLIDE GATE CLOSED
GATE VALVE OPEN
TO POND SPLITTER BOX
FUTURE PIPE
CHEMICAL CLARIFIER
WEIR
SLIDE GATE OPEN
EFFLUENT CHANNEL
EFFLUENT CHEMICAL CLARIFIER

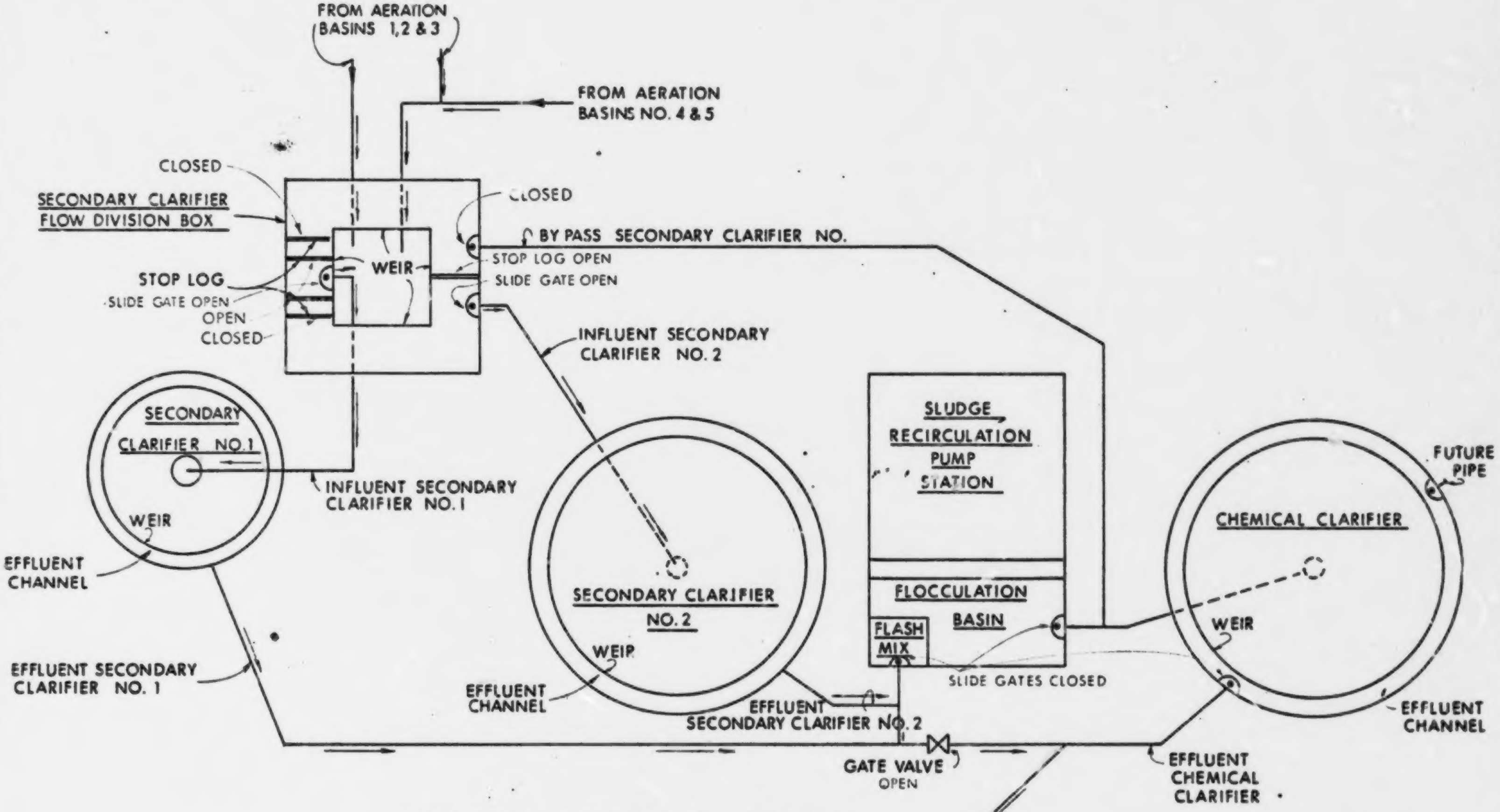
SECONDARY AND CHEMICAL CLARIFIERS

SECONDARY CLARIFIER NO. 2

OUT OF SERVICE

PLANT FLOW GREATER THAN 4 M.G.D.

FIGURE - 11


FROM AERATION BASINS 1,2 & 3
FROM AERATION BASINS NO. 4 & 5
CLOSED
SECONDARY CLARIFIER FLOW DIVISION BOX
STOP LOG
SLIDE GATE OPEN
OPEN
CLOSED
WEIR
CLOSED
BY PASS SECONDARY CLARIFIER NO.
STOP LOG OPEN
SLIDE GATE OPEN
INFLUENT SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO.1
WEIR
INFLUENT SECONDARY CLARIFIER NO.1
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 2
WEIR
EFFLUENT CHANNEL
EFFLUENT SECONDARY CLARIFIER NO. 2
SLUDGE RECIRCULATION PUMP STATION
FLOCCULATION BASIN
FLASH MIX
SLIDE GATES CLOSED
GATE VALVE OPEN
TO POND SPLITTER BOX
CHEMICAL CLARIFIER
FUTURE PIPE
WEIR
EFFLUENT CHANNEL
EFFLUENT CHEMICAL CLARIFIER

SECONDARY AND CHEMICAL CLARIFIERS
FLASH MIX , FLOCCULATION BASINS,
OR CHEMICAL CLARIFIER-OUT OF SERVICE

FIGURE-12

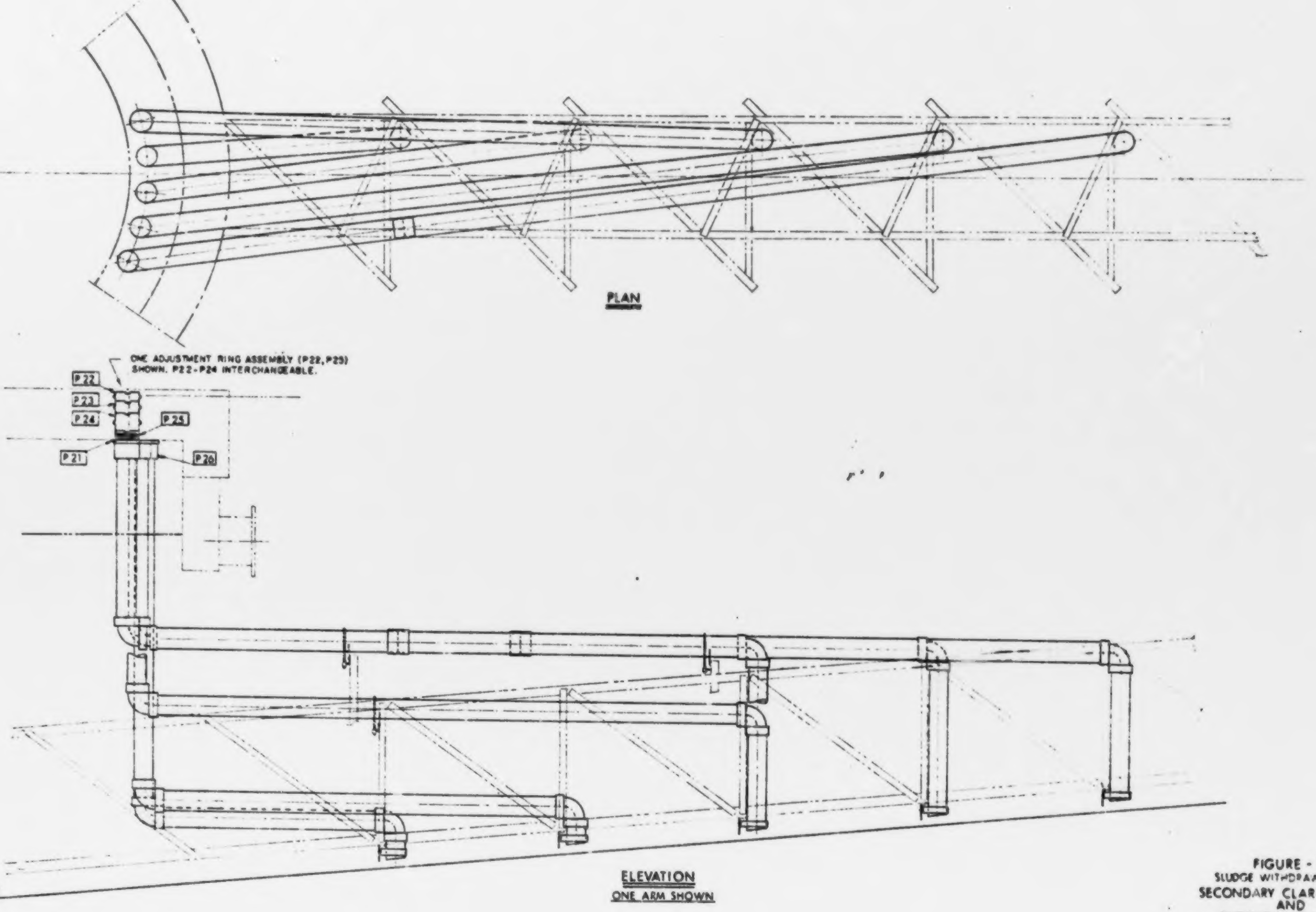

PLAN
ONE ADJUSTMENT RING ASSEMBLY (P22, P23) SHOWN. P22-P24 INTERCHANGEABLE.
P22
P23
P24
P25
P21
P26
ELEVATION
ONE ARM SHOWN

FIGURE - 13
SLUDGE WITHDRAWAL PIPES
SECONDARY CLARIFIER NO 2
AND
CHEMICAL CLARIFIER

Secondary sludge pumps 1, 2, and 3 are equipped with Vari-Drives which permit varying the pumping rates over the following ranges:

Secondary Sludge Pump	Rate - gpm
1.	400-1,800
2.	400,1,800
3.	100-450

Figure 14 shows the valve positions and flow patterns for normal operation:

1. Secondary sludge pumps No. 1 and 2 are pumping return activated sludge from sump No. 1, through the sludge density meter, to the sludge flow division box.

2. Secondary sludge pump No. 3 is pumping chemical sludge from sump No. 2 to the lime mud thickener.

3. Secondary sludge pump No. 4 periodically pumps activated sludge from the sludge hopper in secondary clarifier No. 2, through the sludge density meter, to the sludge flow division box.

4. Secondary sludge pump No. 5. periodically pumps chemical sludge from sump No. 2 to the lime mud thickener.

5. Once every shift, secondary sludge pumps No. 4 and 5 should be turned on and run for 5 minutes.

Figure 15 shows the valve positions and flow patterns if secondary sludge pump No. 1 is out of service. Under this procedure, secondary sludge pump No. 2 pumps all of the return activated sludge. The length of this shutdown should be kept to a minimum, because is is poor practice to run secondary sludge pump No. 2 at a high rate of flow for extended periods of time.

Figure 16 shows the valve positions and flow patterns if secondary sludge pump No. 2 is out of service.

Figure 17 shows the valve positions and flow patterns if secondary sludge pump No. 3 is out of service.

If secondary sludge pump No. 4 is out of service, secondary sludge pump No. 5 is used to pump sludge from the hoppers in secondary clarifier No. 2 and the chemical clarifier.

If secondary sludge pump No. 5 is out of service, secondary sludge pump No. 4 is used to pump sludge from the sludge hoppers in secondary clarifier No. 2 and the chemical clarifier.

Figure 18 shows the procedure for backflushing the sludge lines from the sludge hoppers of secondary clarifier No. 2 and the chemical clarifier, by reversing secondary sludge pumps No. 4 and 5. The sludge

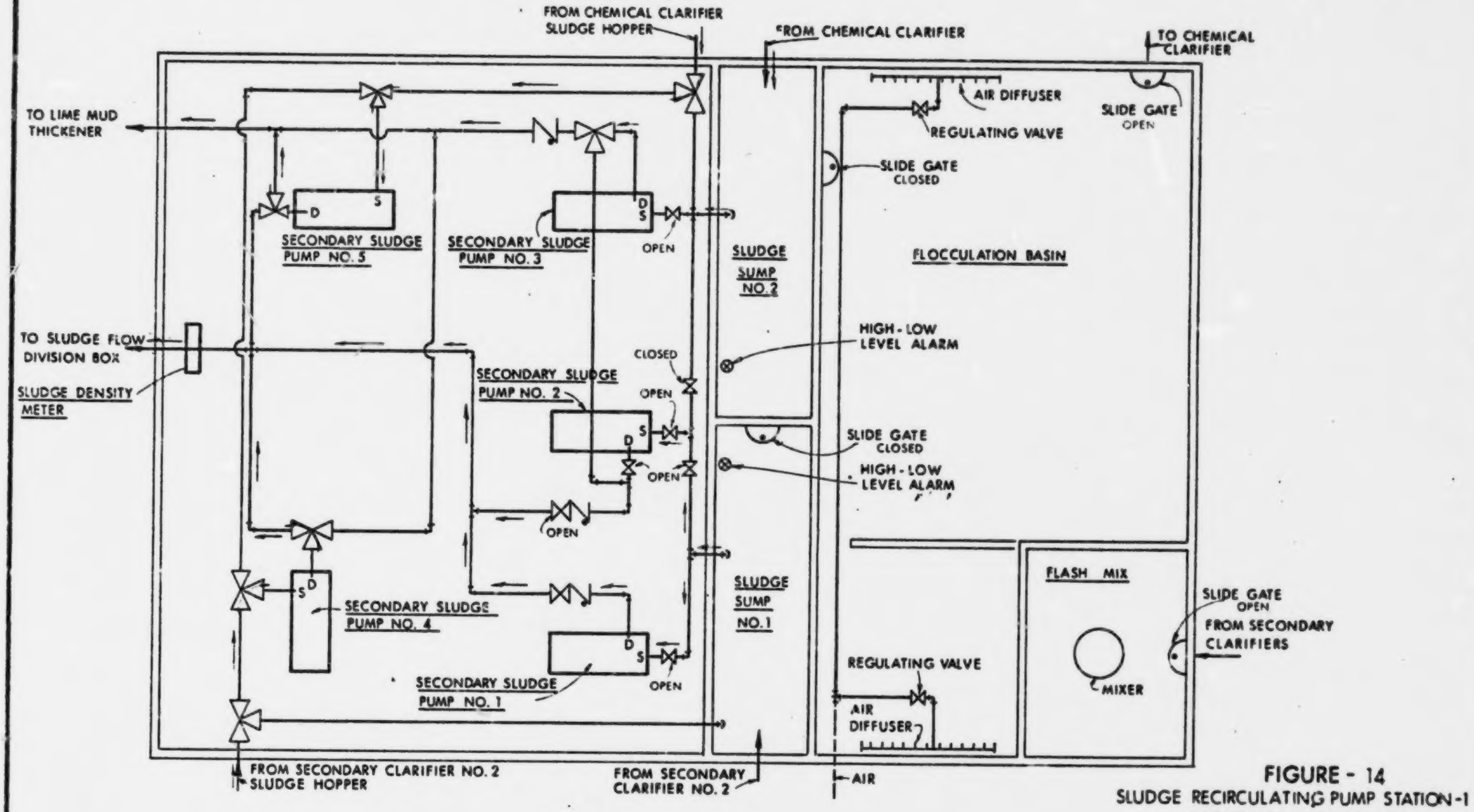


FIGURE - 14
SLUDGE RECIRCULATING PUMP STATION-1
NORMAL OPERATION

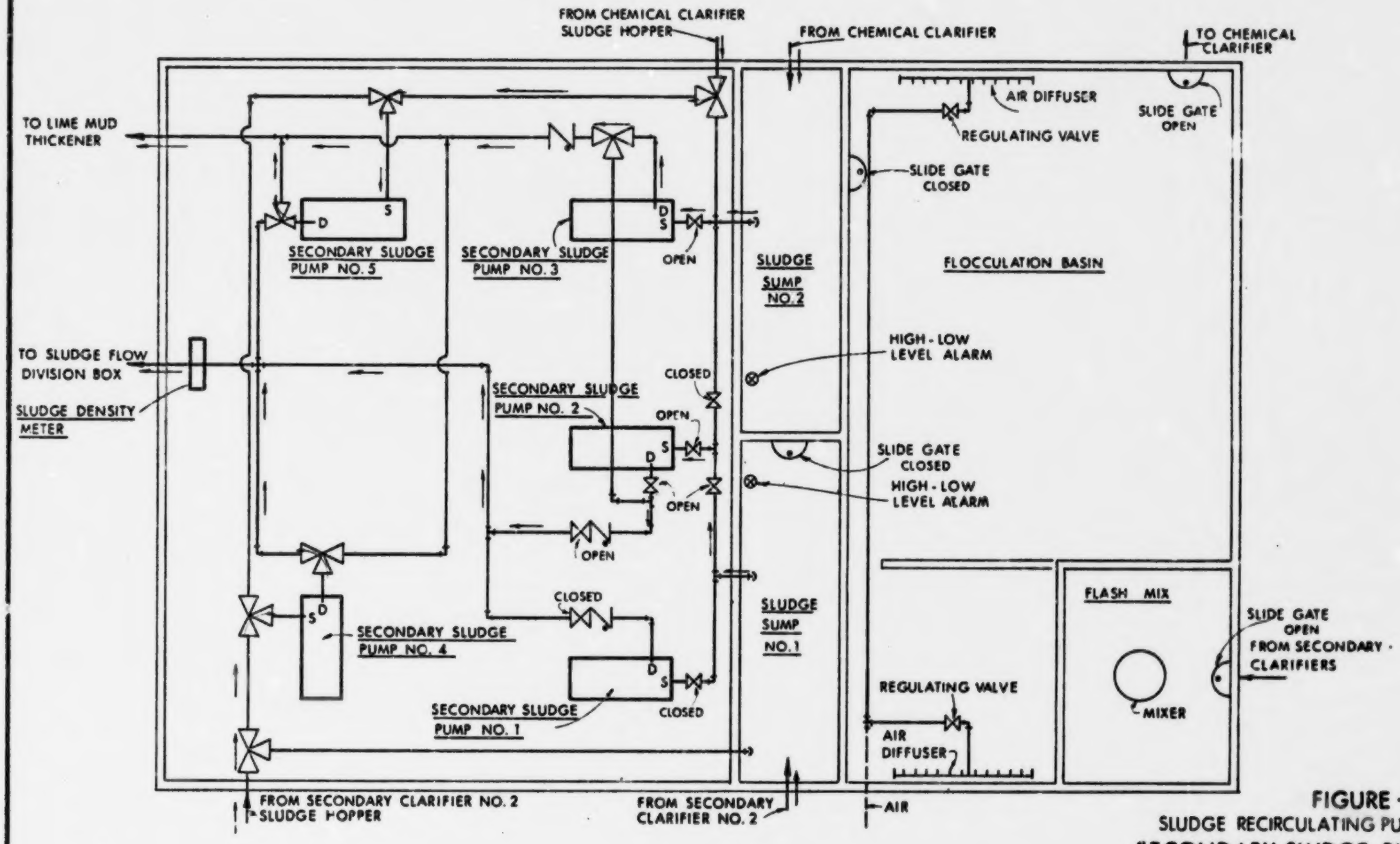


FIGURE - 15
SLUDGE RECIRCULATING PUMP STATION-1
SECONDARY SLUDGE PUMP NO.1
OUT OF SERVICE

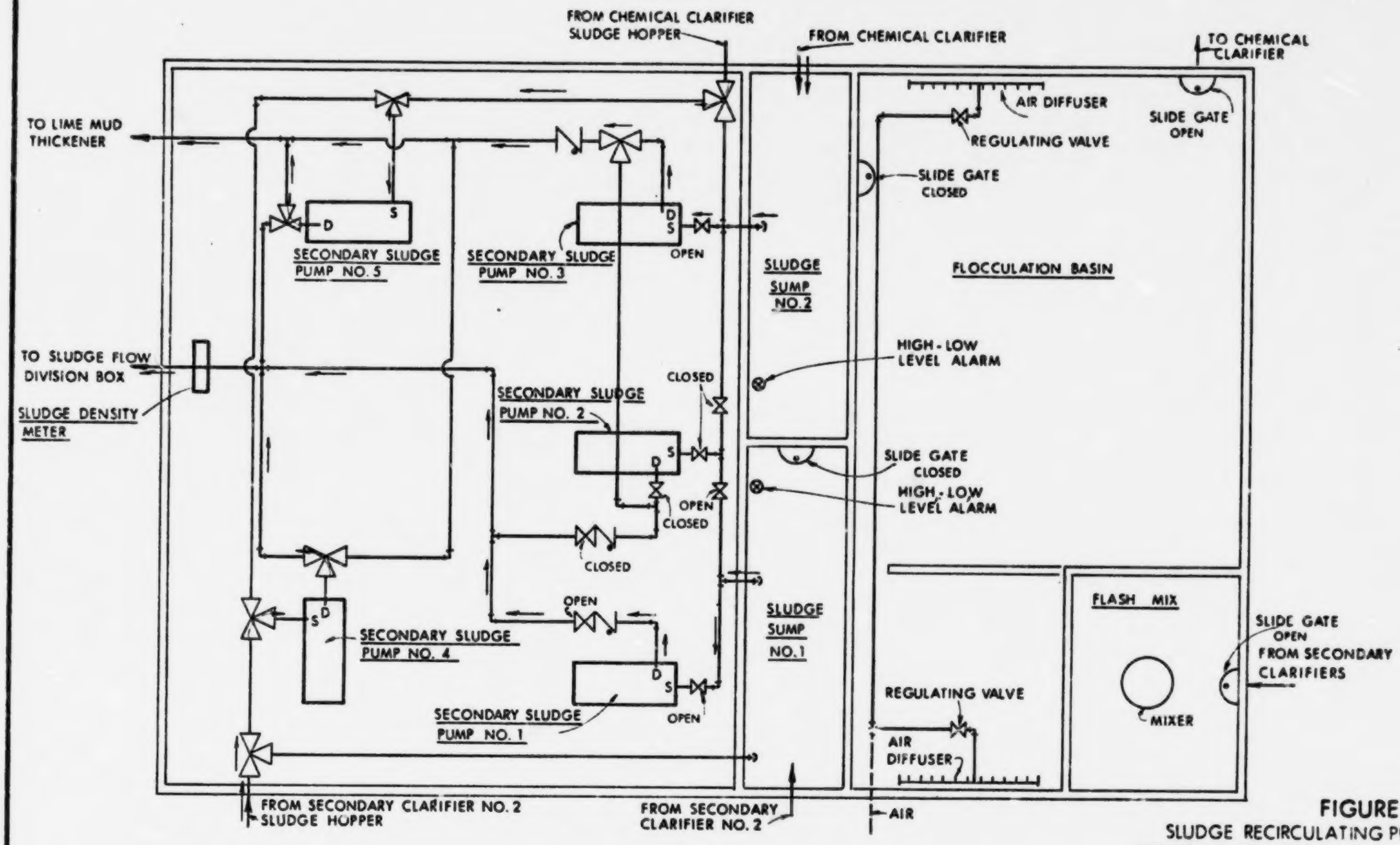


FIGURE - 16
SLUDGE RECIRCULATING PUMP STATION-1
SECONDARY SLUDGE PUMP NO. 2
OUT OF SERVICE

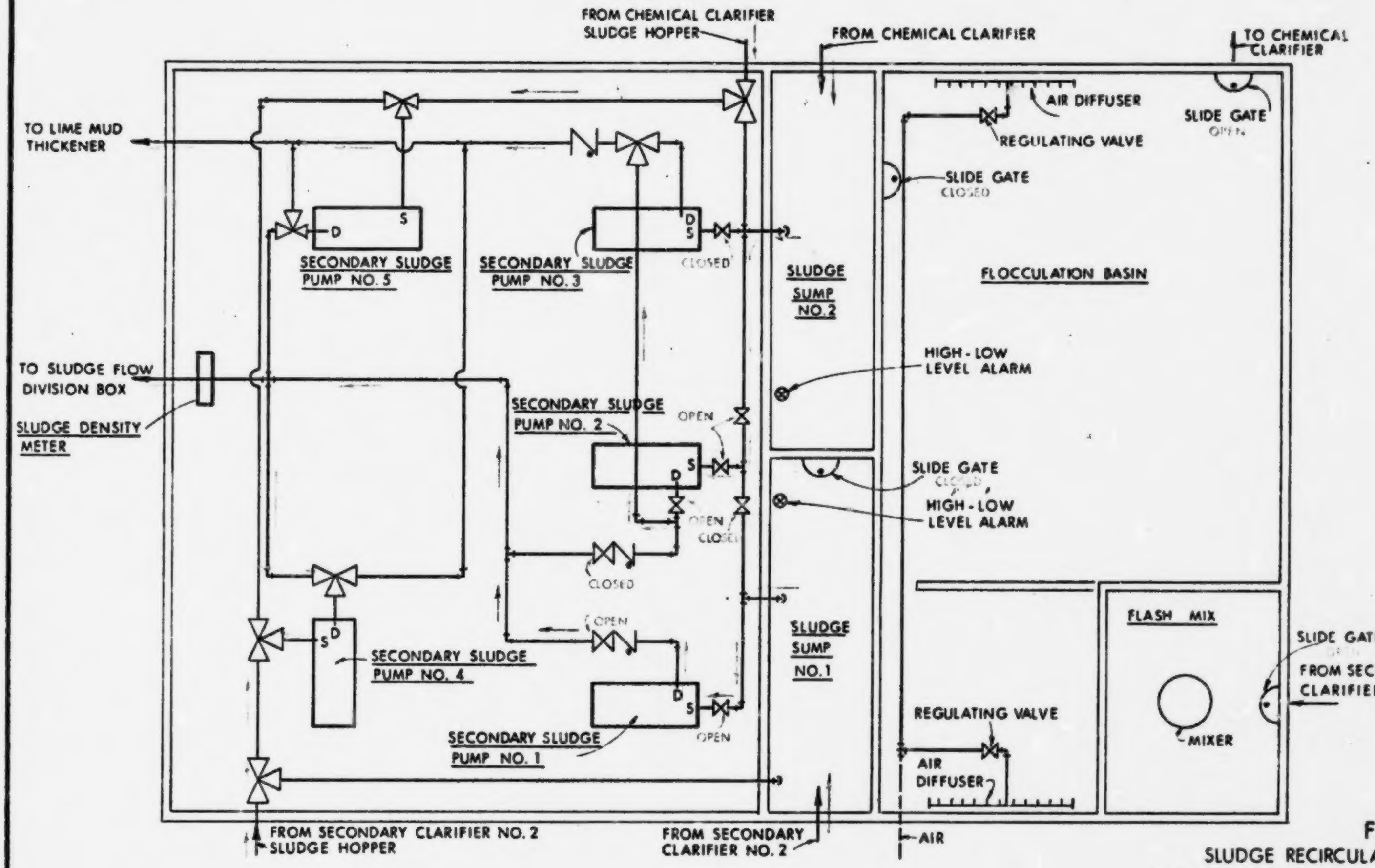


FIGURE - 17
SLUDGE RECIRCULATING PUMP STATION-1
SECONDARY SLUDGE PUMP NO. 3
OUT OF SERVICE

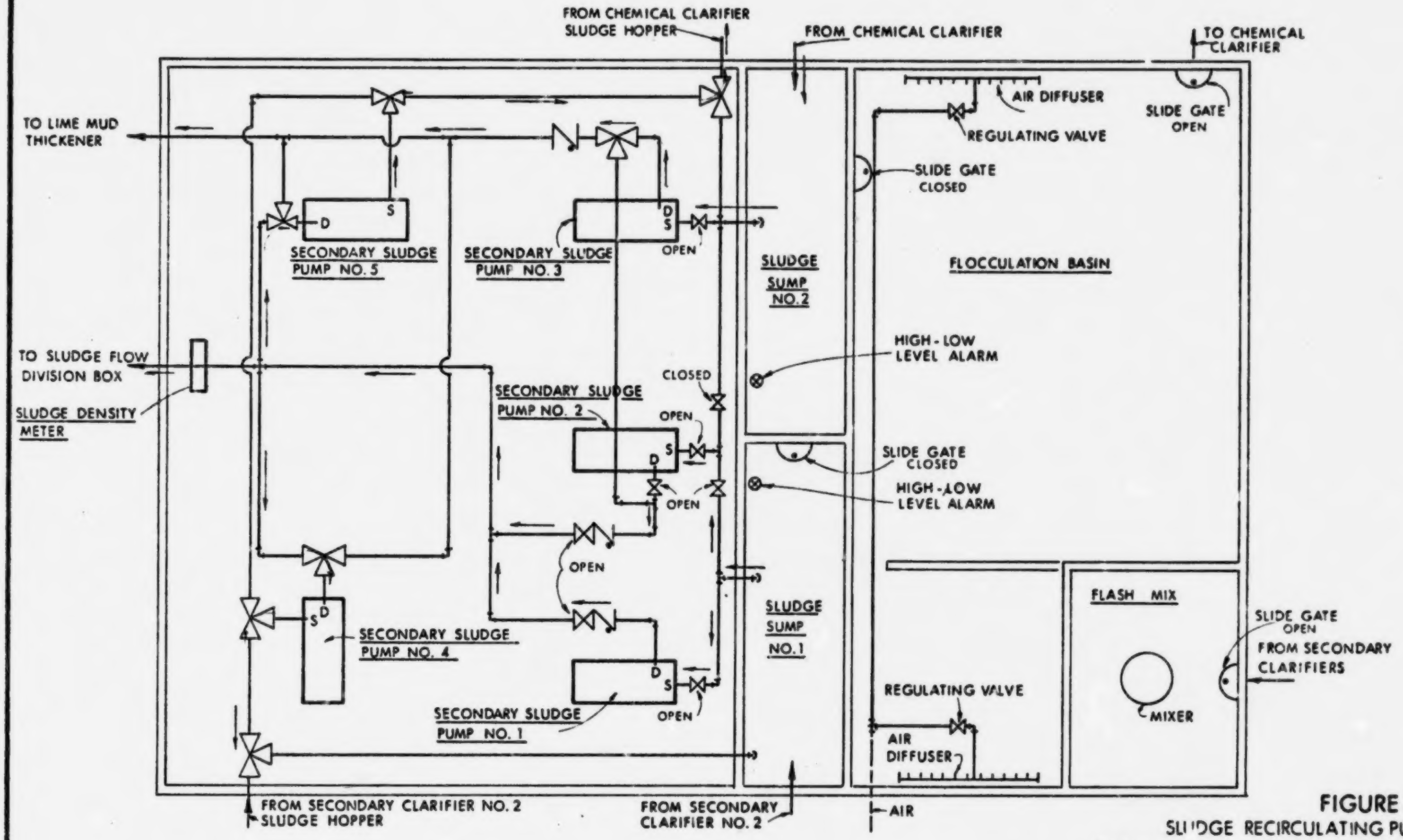


FIGURE - 18

SLUDGE RECIRCULATING PUMP STATION-1

BACK FLUSH SLUDGE LINES FROM SECONDARY CLARIFIER NO. 2 AND CHEMICAL CLARIFIER

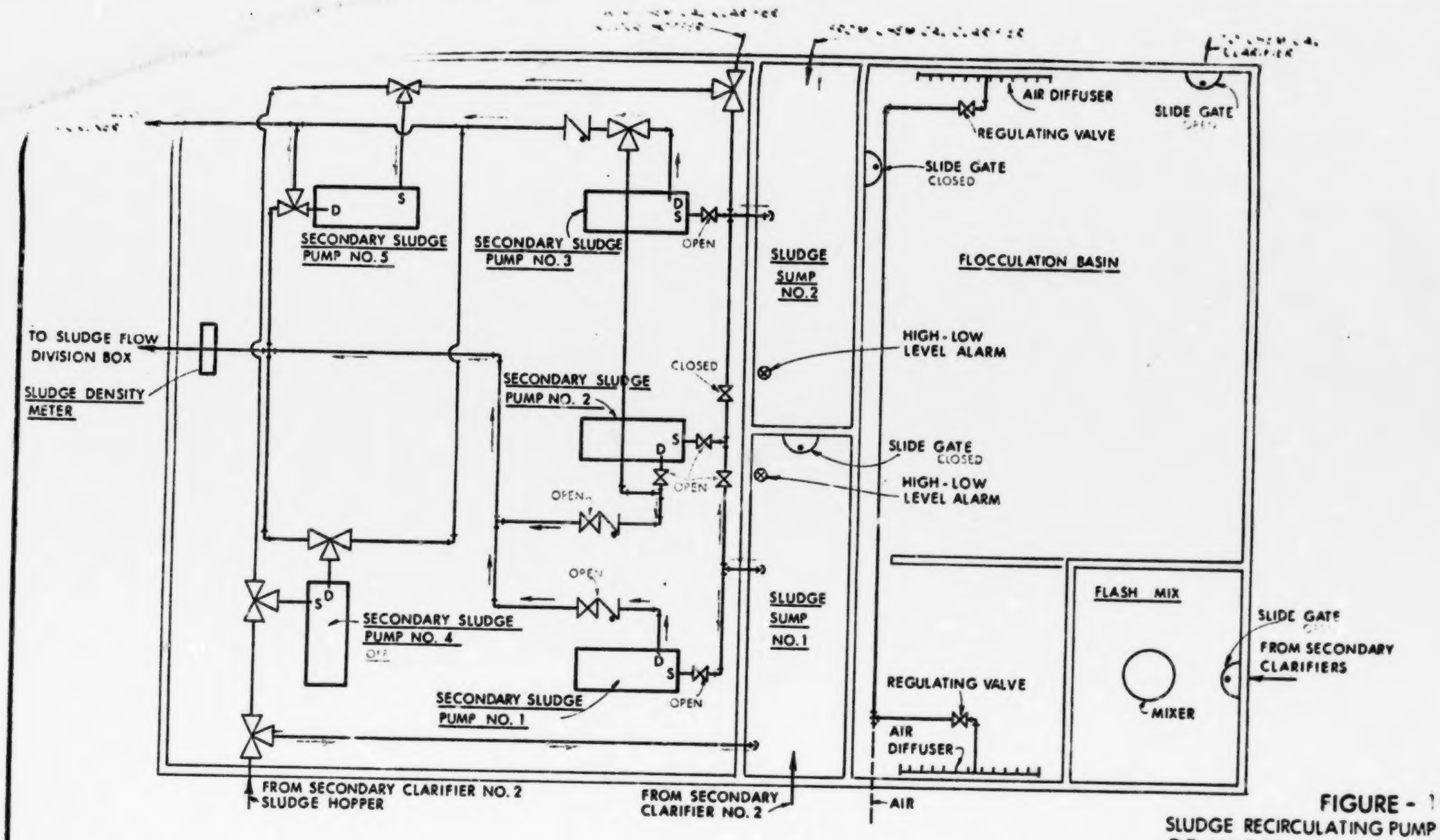


FIGURE - 19
SLUDGE RECIRCULATING PUMP STATION-1
DE-WATERING SECONDARY
CLARIFIER NO. 2

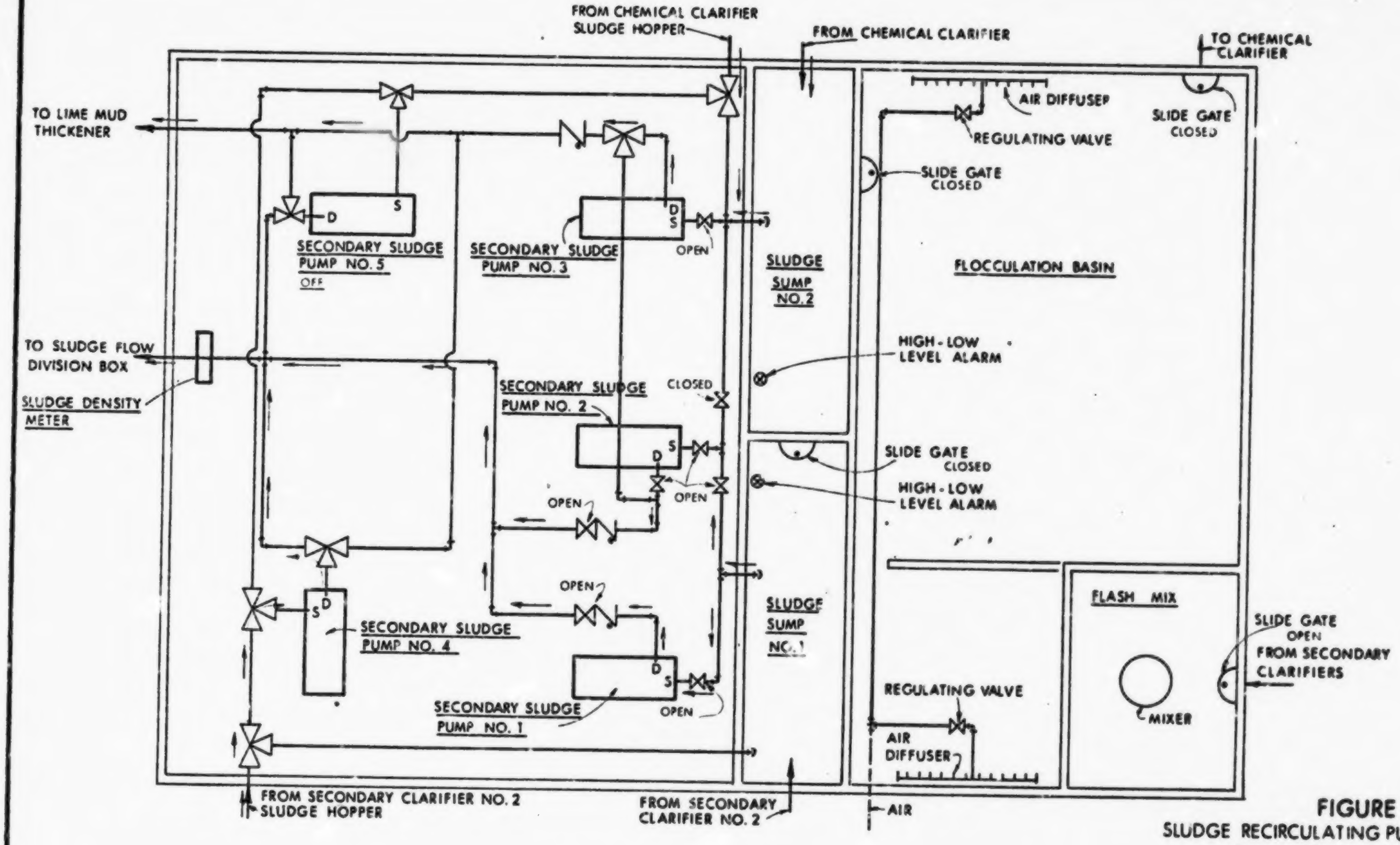


FIGURE - 20
SLUDGE RECIRCULATING PUMP STATION - 1
DE-WATERING CHEMICAL CLARIFIER

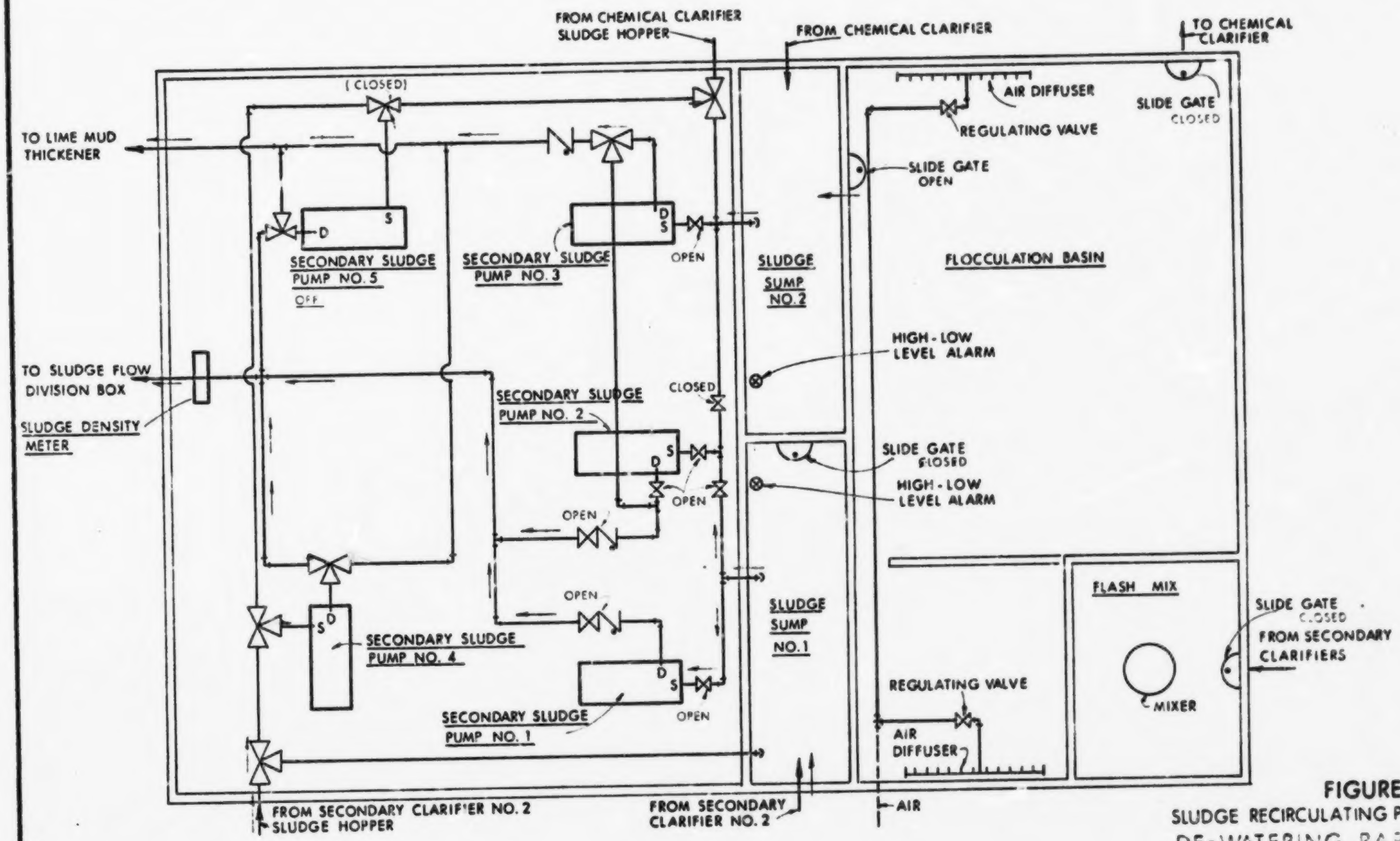


FIGURE - 21
SLUDGE RECIRCULATING PUMP STATION-1
DE-WATERING RAPID MIX AND
FLOCCULATION BASINS

line under secondary clarifier No. 2 should be flushed once a week for 15 minutes. The sludge line under the chemical clarifier should be flushed every third day for 15 minutes.

Figure 19 Shows the procedure for pumping secondary clarifier No. 2 down.

Figure 20 shows the procedure for pumping the chemical clarifier down.

Figure 21 shows the procedure for pumping the flash mix and flocculation basins down. The details of the sludge density meter and the sludge density amplifier are discussed later.

It is important that the pumping rates of these pumps adjusted so that the sludge level in both sludge sumps 1 and 2 be maintained at a constant level at approximately six feet. A High-Low level alarm will ring in the Operations Building at the following sludge depths:

Sump No.	Sludge Level High Alarm	Sludge Level Low Alarm
1.	12 ft.	3 ft.
2.	8.5 ft.	2 ft.

If sludge is being removed by the suction pipes in either secondary clarifier No. 2 or the chemical clarifier at a faster rate than the pumps are pumping, then the sludge level will rise and initiate the High/Low Level recirculating P.S. sump alarm in the Operations Building.

On the other hand, if sludge is being pumped from either sludge sump 1 or 2 faster than sludge is being removed by the suction pipes in either secondary clarifier No. 2 or the chemical clarifier then the sludge level will drop and actuate the low level alarm. This will ring the High/Low Level recirculation P.S. sump alarm in the Operations Building. In addition, the low level alarm will shutdown the pumps which normally pump from either sump. This means if low level occurs in sludge sump No. 1, then secondary sludge pumps 1 and 2 will be shutdown. If low level occurs in sludge sump No. 2, then secondary sludge pump No. 3 will be shutdown.

The High/Low level recirc. P.S. sump alarm in the Operations Building does not indicate the cause of failure. Inspection of the running lights for secondary sludge pumps 1, 2, and 3, in Panel 41 will indicate the following:

1. If the running lights are ON for the three secondary sludge pumps, the high sump level has occurred. The operator should immediately determine which sump caused the alarm and increase the pumping rates on the necessary pumps.

2. If the running lights for secondary sludge pumps 1 and 2 are OFF, then low level has occurred in sump No. 1. The pumping rates should immediately be reduced for secondary sludge pumps 1 and 2.

3. If the running light for secondary sludge pump No. 3 is off, the low level has occurred in sump No. 2. The pumping rate should immediately be reduced for secondary sludge pump No. 3.

After the pumping rates have been adjusted, the center well of the clarifier which is feeding sludge to the particular sludge sump should be checked out. A slipped ring could cause a high level alarm and a plugged suction pipe could cause a low level alarm. If the suction pipes appear to be operating properly, then the alarm was probably caused by a large fluctuation in flow through the plant. Be sure to note the malfunction in the log for possible future use. Before returning to the Operations Building, check the sludge level in the sludge sumps to insure that the liquid level is being maintained at a constant rate. Secondary sludge pumps No. 4 and 5 normally pump from the center hopper of secondary clarifier No. 2 and the chemical clarifier and are not connected to the sludge sump level alarm.

Recirculation Pump Station No. 2. The purpose of recirculation pump station No. 2 is to pump settled activated sludge from secondary clarifier No. 1 to the sludge flow division box. The facilities in recirculation pump station No. 2 are:

1. Secondary Sludge Pump Nos. 6 and 7

2. Flow Meters

Figure 22 shows the valve positions and flow patterns for normal operation. Figure 22 shows secondary sludge pump No. 6 operating alone. However, secondary sludge pump No. 7 can be operated alone with the same valve positions, or if necessary, both pumps (Nos. 6 and 7) can be operated at the same time.

Figure 23 shows the valve positions and flow patterns for pumping activated sludge to the primary clarifiers. The only time that this pumping scheme will be used is when the waste activated sludge thickener is out of service. This procedure is called "wasting" activated sludge.

When it is desired to take secondary clarifier No. 1 out of service, the influent flow is first turned off, as shown in Figure 8 or 9. Then this basin is pumped down as shown in Figure 22 for normal operation.

Flow meter No. 1 measures the amount of activated sludge returned to the sludge flow division box.

Flow meter No. 2 measures the amount of "sludge wasted" or activated sludge pumped to the primary clarifiers.

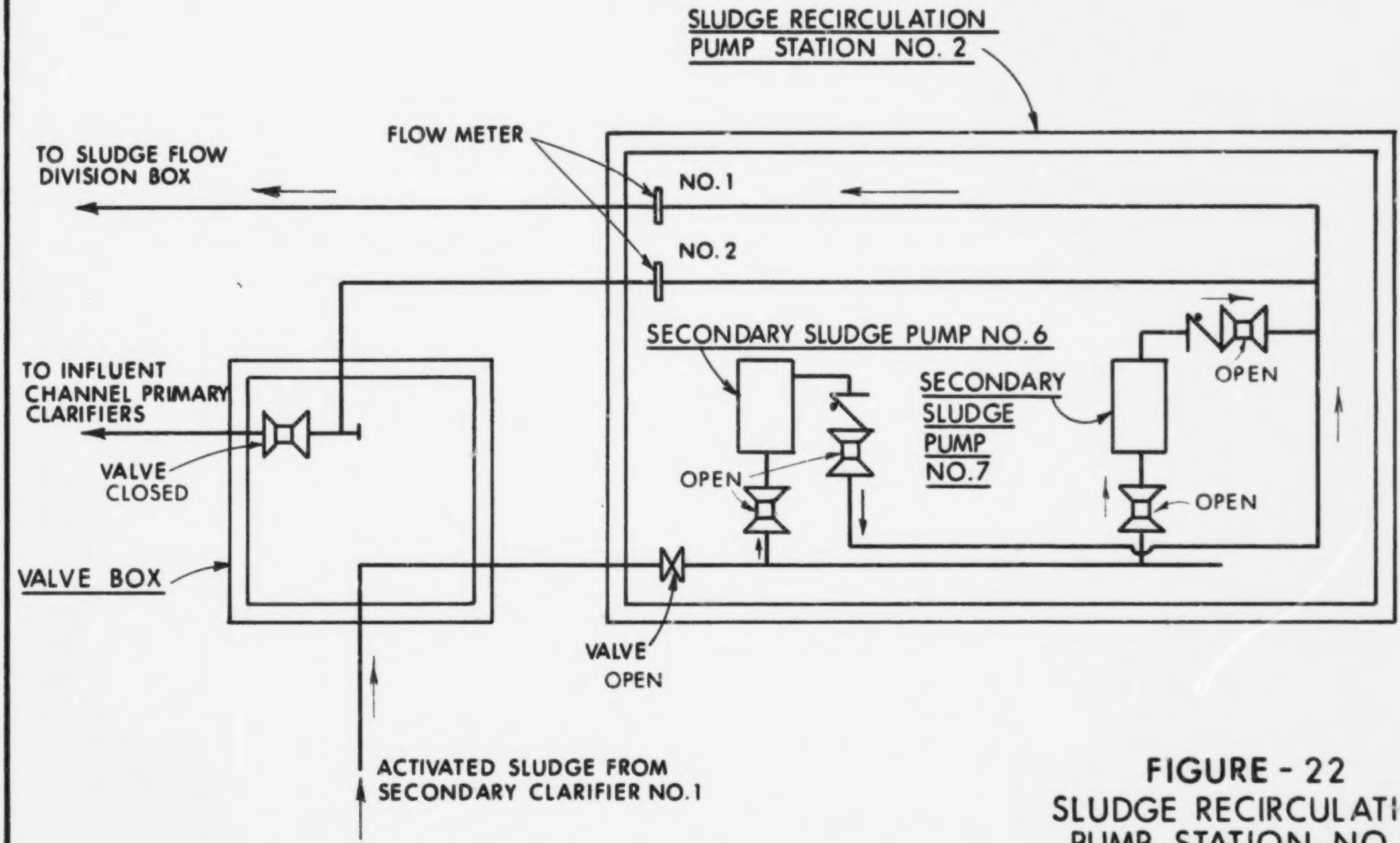


FIGURE - 22
SLUDGE RECIRCULATION
PUMP STATION NO. 2
NORMAL OPERATION

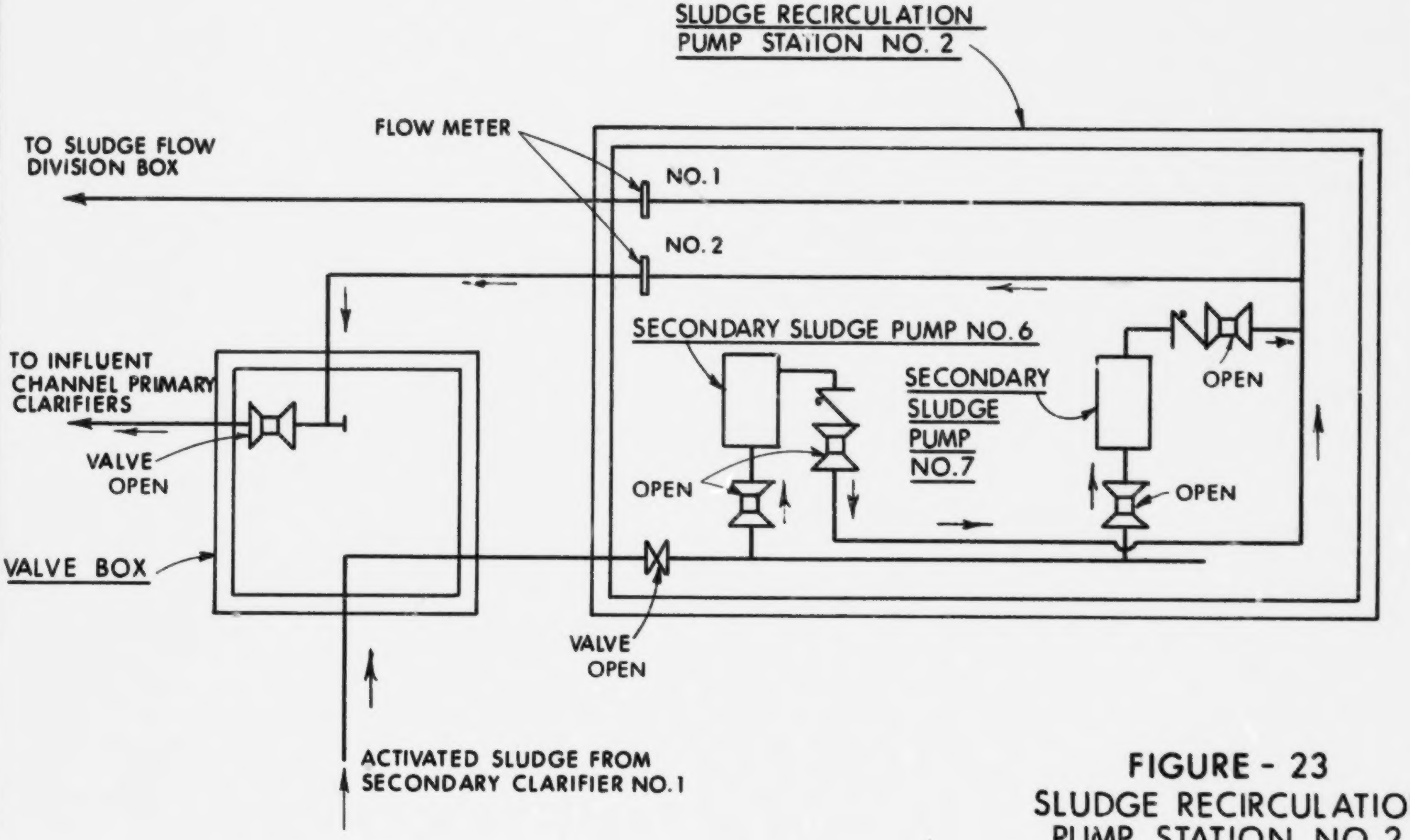

SLUDGE RECIRCULATION
PUMP STATION NO. 2
FLOW METER
TO SLUDGE FLOW DIVISION BOX
NO. 1
NO. 2
SECONDARY SLUDGE PUMP NO. 6
SECONDARY SLUDGE PUMP NO. 7
OPEN
OPEN
OPEN
TO INFLUENT CHANNEL PRIMARY CLARIFIERS
VALVE OPEN
VALVE BOX
VALVE OPEN
ACTIVATED SLUDGE FROM SECONDARY CLARIFIER NO. 1

FIGURE - 23
SLUDGE RECIRCULATION
PUMP STATION NO. 2
SLUDGE THICKENER OUT OF SERVICE

Sludge Flow Division Box. Figure 24 shows the gate position and flow patterns for normal operation. Return sludge from recirculation pump station Nos. 1 and 2 is pumped to the center box. The total amount of return sludge pumped from these two pump stations is measured by a bubbler tube. This flow is indicated in the return sludge control center located in the operations building (See Figure 28 for details). In order to insure that accurate flow measurements of return sludge are being made, it is important that the pressure regulating valve on the bubbler be set for 20 psi. Flow meter No. 2 measures the amount of "sludge wasted" or activated sludge pumped directly to the primary clarifiers during emergency bypassing of the sludge thickener. The return sludge then flows over weirs 6-44 and 6-45. The return sludge flowing over 6-44 flows to aeration basins 1, 2, and 3, where it is mixed with the effluent from primary clarifier No. 1. The return sludge flowing over 6-45 flows to aeration basins No. 4 and 5, where it is mixed with the effluent from primary clarifier No. 2.

In addition to serving as a sludge splitter box, the sludge flow division box regulates the amount of sludge to be wasted from the activated sludge process to the flotation thickener. The waste sludge flows through the magnetic flow meter, which measures the quantity of sludge wasted to the flotation thickener. The controls for the magnetic flow meter and the butterfly valve are located in the return sludge control center, located in the Operations Building (See Figure 28 for details).

If primary clarifier No. 1 is out of service, then Figure 25 shows the valve positions and flow patterns of return activated sludge.

Figure 26 shows the valve positions and flow patterns of return activated sludge if primary clarifier No. 2 is out of service.

Figure 27 shows the valve positions if the flotation thickener is out of service. Under this method of operation, see Figure 23 for other details.

Return Sludge, Control Center. The return sludge control center is located in a panel in the Operations Building. The purpose of this center is to regulate the activated sludge process. Figure 28 shows the instruments in this panel. The instruments include:

1. Total Return Sludge Flow: This meter indicates the total amount of sludge being pumped back to the sludge flow division box from recirculation sludge pump stations No. 1 and 2. The return sludge flow is measured in gpm. The flow is measured by the bubbler tube in the sludge flow division box.

2. Secondary Clarifier Underflow, Percent Solids: This meter indicates and records the percent solids or solids content in the return sludge being pumped to the sludge flow division box. The solids content is measured by the sludge density gauge located in sludge recirculation pump station No. 1. The chart on this meter should be changed as required.

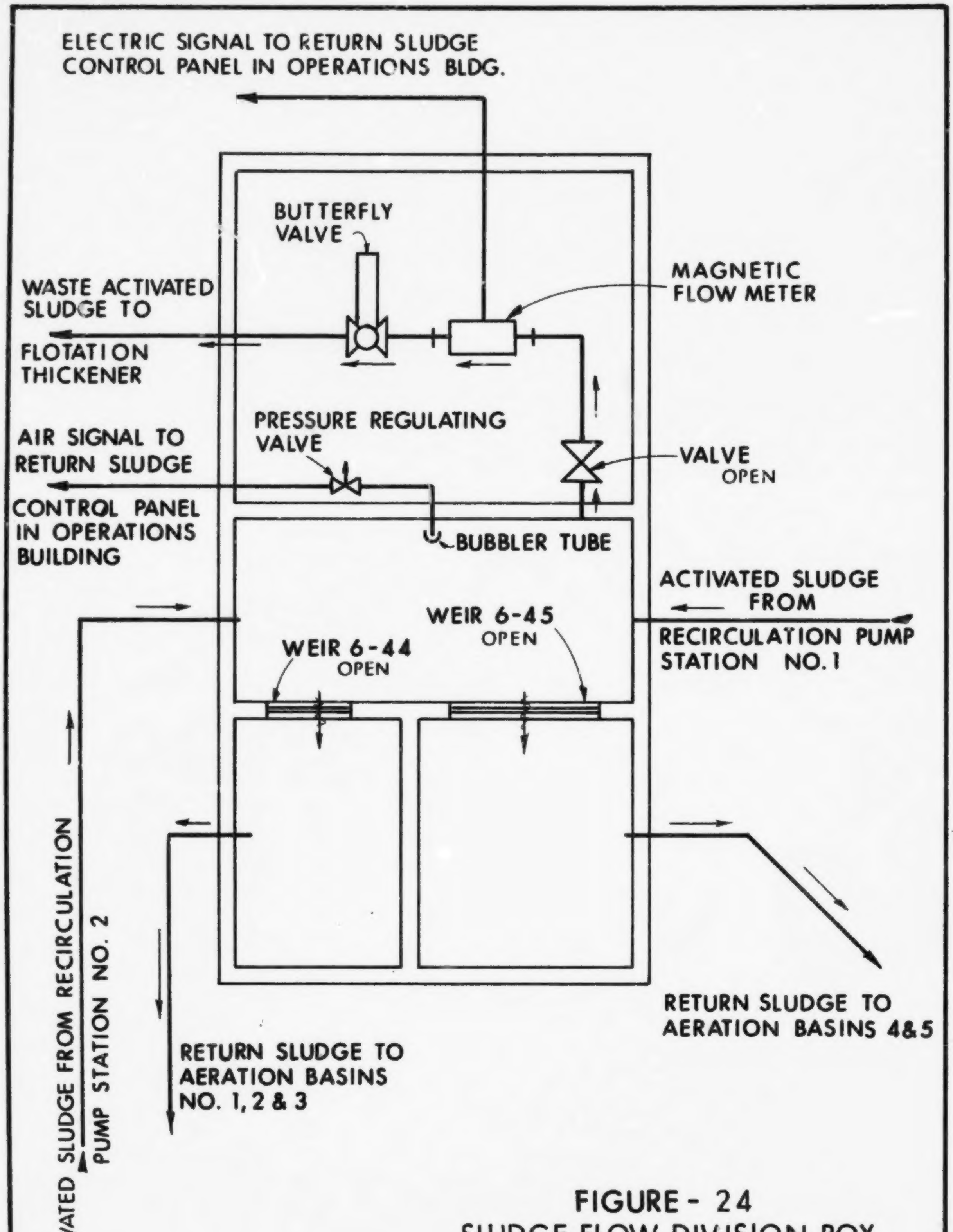

ELECTRIC SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BLDG.
BUTTERFLY VALVE
MAGNETIC FLOW METER
WASTE ACTIVATED SLUDGE TO FLOTATION THICKENER
PRESSURE REGULATING VALVE
AIR SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BUILDING
VALVE OPEN
BUBBLER TUBE
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 1
WEIR 6-45 OPEN
WEIR 6-44 OPEN
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 2
RETURN SLUDGE TO AERATION BASINS NO. 1, 2 & 3
RETURN SLUDGE TO AERATION BASINS 4&5

FIGURE - 24
SLUDGE FLOW DIVISION BOX
NORMAL OPERATION

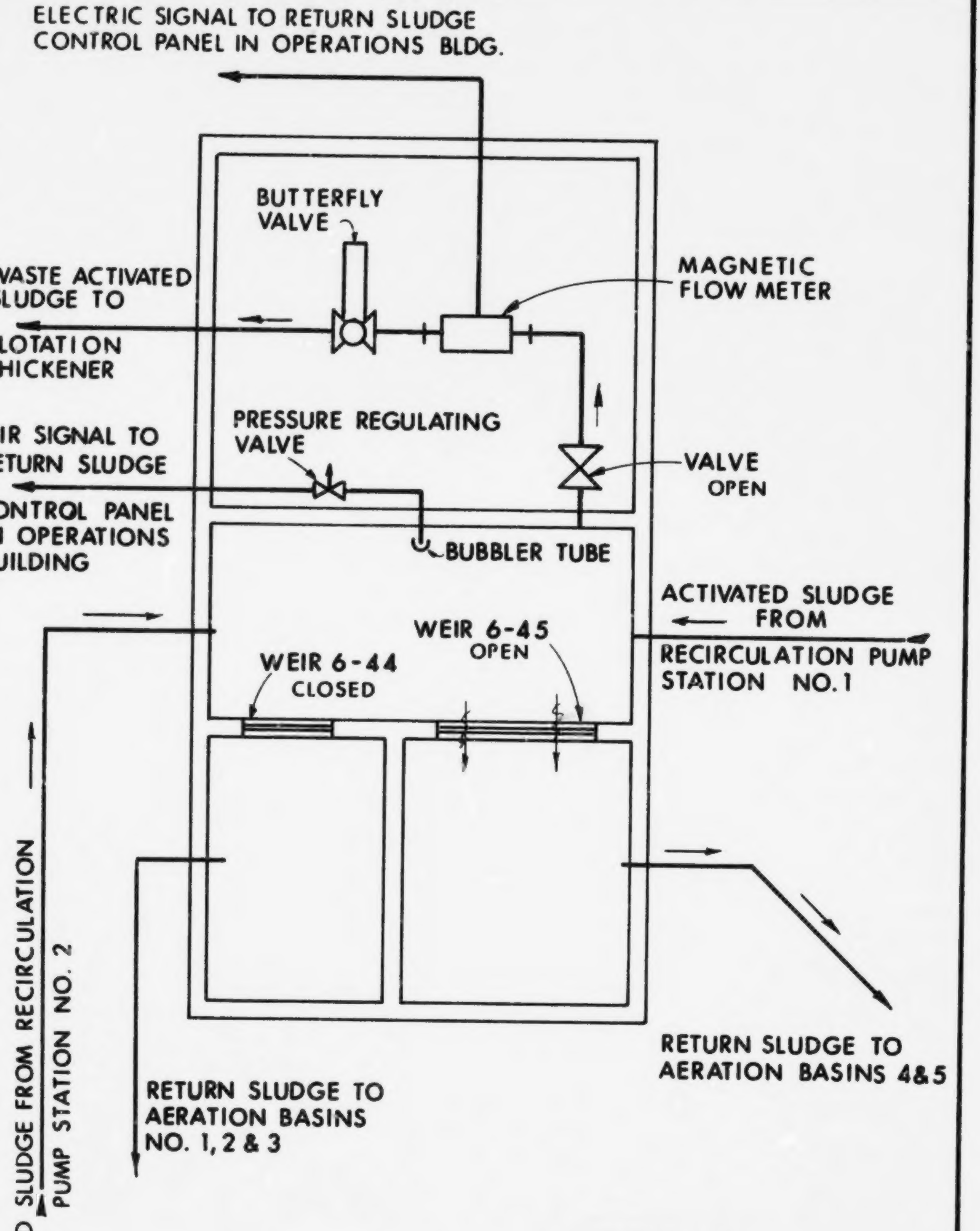

ELECTRIC SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BLDG.
BUTTERFLY VALVE
WASTE ACTIVATED SLUDGE TO FLOTATION THICKENER
MAGNETIC FLOW METER
PRESSURE REGULATING VALVE
AIR SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BUILDING
VALVE OPEN
BUBBLER TUBE
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 1
WEIR 6-45 OPEN
WEIR 6-44 CLOSED
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 2
RETURN SLUDGE TO AERATION BASINS NO. 1, 2 & 3
RETURN SLUDGE TO AERATION BASINS 4&5

FIGURE - 25
SLUDGE FLOW DIVISION BOX
PRIMARY CLARIFIER NO. 1
OUT OF SERVICE

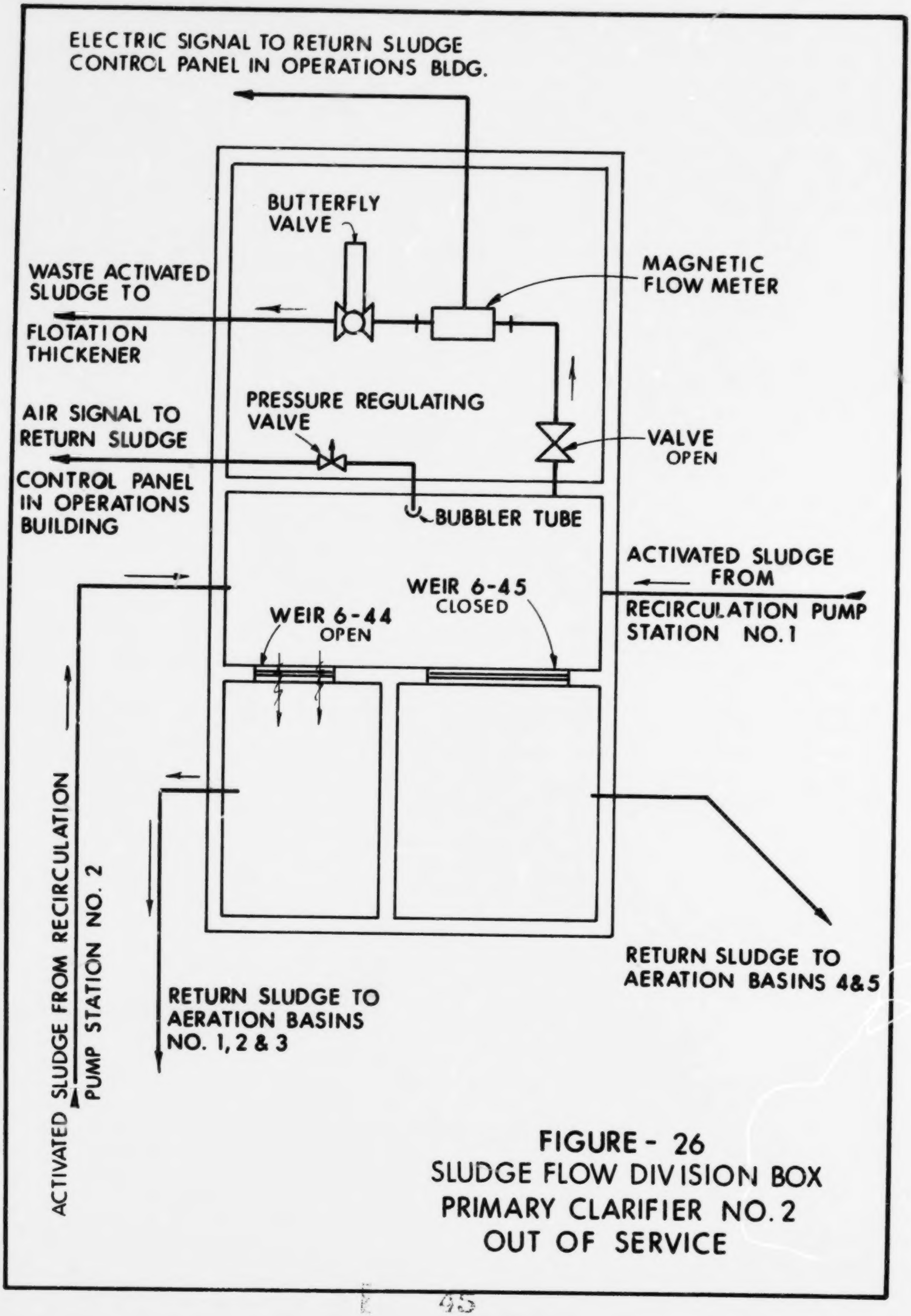

ELECTRIC SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BLDG.
BUTTERFLY VALVE
MAGNETIC FLOW METER
WASTE ACTIVATED SLUDGE TO FLOTATION THICKENER
PRESSURE REGULATING VALVE
AIR SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BUILDING
VALVE OPEN
BUBBLER TUBE
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 1
WEIR 6-45 CLOSED
WEIR 6-44 OPEN
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 2
RETURN SLUDGE TO AERATION BASINS NO. 1, 2 & 3
RETURN SLUDGE TO AERATION BASINS 4&5

FIGURE - 26
SLUDGE FLOW DIVISION BOX
PRIMARY CLARIFIER NO. 2
OUT OF SERVICE

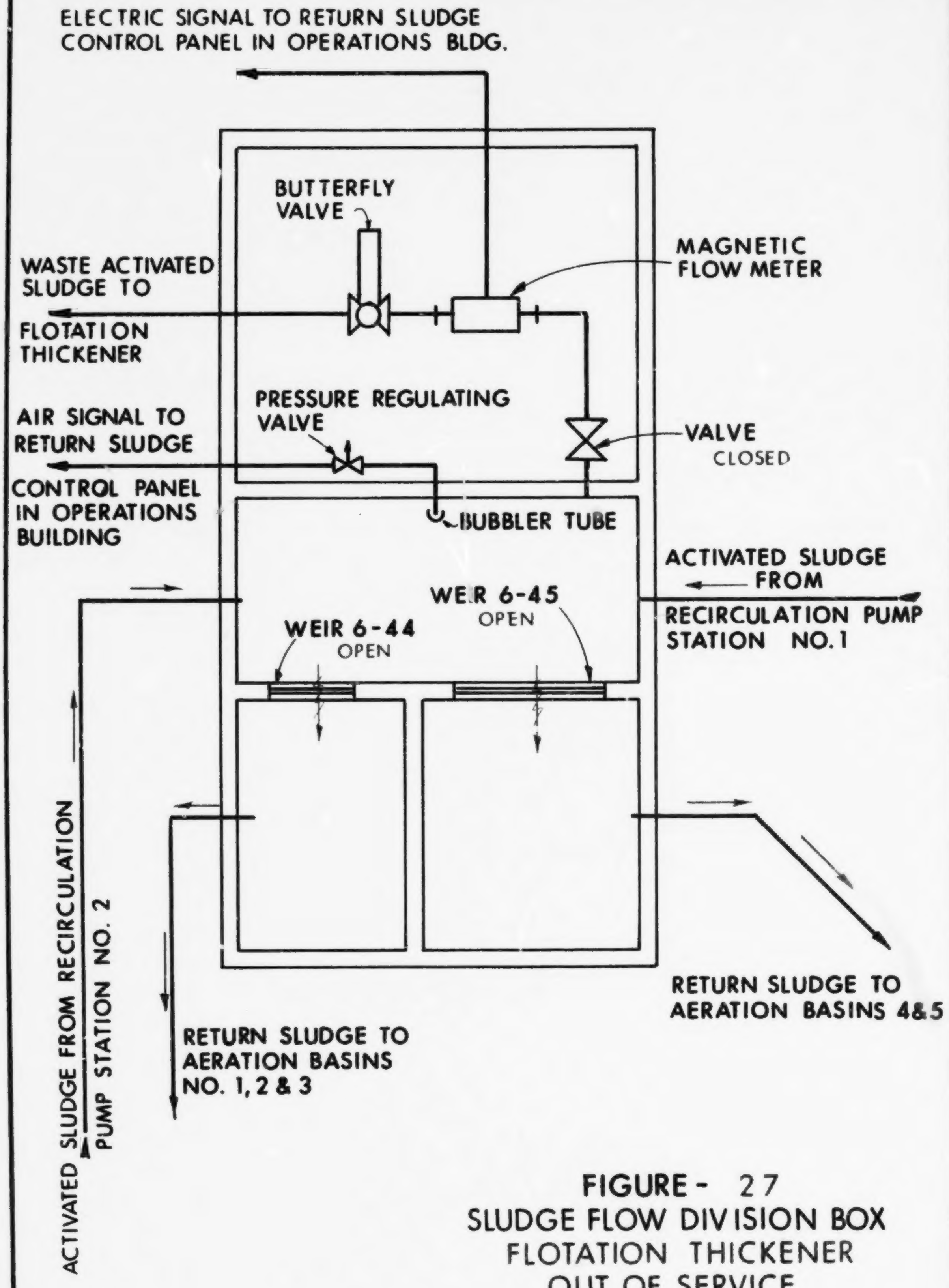
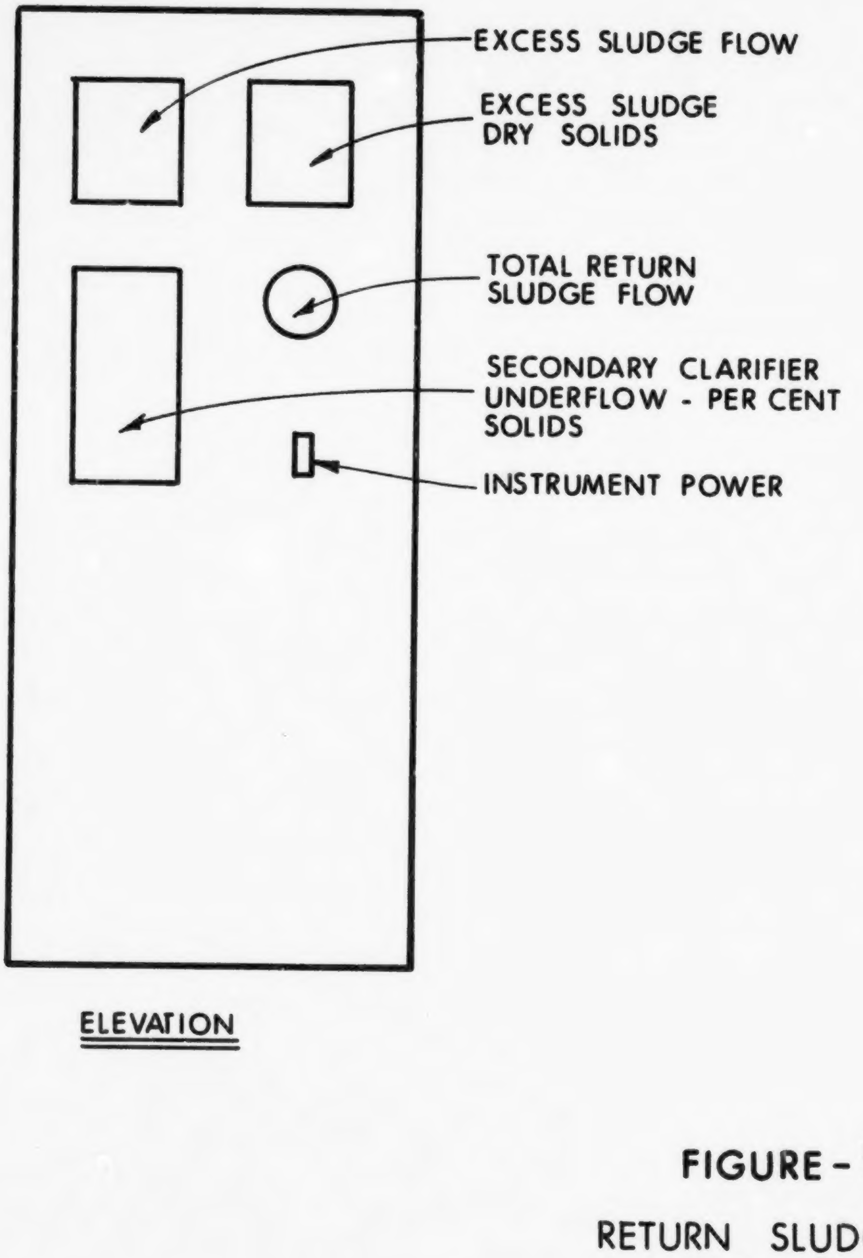

ELECTRIC SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BLDG.
BUTTERFLY VALVE
MAGNETIC FLOW METER
WASTE ACTIVATED SLUDGE TO FLOTATION THICKENER
PRESSURE REGULATING VALVE
AIR SIGNAL TO RETURN SLUDGE CONTROL PANEL IN OPERATIONS BUILDING
VALVE CLOSED
BUBBLER TUBE
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 1
WEIR 6-45 OPEN
WEIR 6-44 OPEN
ACTIVATED SLUDGE FROM RECIRCULATION PUMP STATION NO. 2
RETURN SLUDGE TO AERATION BASINS NO. 1, 2 & 3
RETURN SLUDGE TO AERATION BASINS 4&5

FIGURE - 27
SLUDGE FLOW DIVISION BOX
FLOTATION THICKENER
OUT OF SERVICE



ELEVATION

FIGURE - 28

RETURN SLUDGE CONTROL CENTER

3. Excess Sludge Flow: This meter indicates and records the rate at which excess sludge is wasted to the flotation thickener. This flow is measured in gpm. The chart on this meter should be changed as required. The excess sludge flow is measured by the magnetic flow meter located in the sludge flow division box.

4. Excess Sludge Dry Solids: This meter indicates, records, and controls the pounds of activated sludge solids wasted to the flotation thickener. The set point on this instrument regulates the butterfly valve located in the sludge flow division box. The details for regulating this instrument are given later.

Raw Sludge and Waste Activated Sludge Pumps. The purpose of the primary and waste activated sludge pumps is to pump primary sludge, scum, and thickened activated sludge to the centrifuges located in the Incineration Building. The equipment in this pump station includes:

1. Sludge Transfer Pump Nos. 1 and 2
2. Sludge Transfer Pump Nos. 3 and 4 are equipped with vari-drives
3. Day Tank
4. High-Low Level Alarm

Figure 29 shows the valve positions and flow patterns for normal operation. Sludge transfer pump No. 1 operates on a time clock and periodically pumps raw sludge from the center sludge hopper of pirmary clarifier No. 2 to the day tank. Sludge transfer pump No. 2 operates on a time clock and periodically pumps raw sludge from the sludge hopper in primary clarifier No. 1 to the day tank. The procedure for setting the time clocks on sludge transfer pumps No. 1 and No. 2 is outlined later. Sludge transfer pump No. 3 pumps scum from primary clarifiers No. 1 and No. 2 to the day tank. This has to be done on a manual basis, once a shift. Sludge transfer pump No. 4 pumps a mixture of thickened waste activated sludge, raw sludge and scum from the day tank to the centrifuges in the Incineration Building. The details of setting the pumping rate are discussed later.

The valve settings and flow patterns of Figure 29 also apply when the waste activated sludge flotation thickener is out of service. However, when this failure occurs, it is no longer possible to waste activated sludge from the sludge flow division box (see Figure 27 for this condition). It is then necessary to waste sludge by pumping the desired amount of waste sludge from secondary clarifier No. 1 directly to the headworks of the plant and permit it to settle out in the primary clarifiers (See Figure 23 sludge recirculation pump station No. 2).

Under this method of operation, sludge transfer pumps 1 and 2 are pumping sludge continuously from the primary clarifiers to the day tank. Scum is pumped manually once a shift by sludge transfer pump No. 3. Sludge transfer pump No. 4 pumps the mixture of sludges in the day tank to the centrifuges in the Incineration Building. It is important that sludge transfer pumps 1 and 2 pump the same amount of sludge as is being pumped by sludge transfer pump No. 4.

Figure 30 shows the valve positions and flow patterns when the centrifuges are out of service. Sludge transfer Pumps 1 and 2 operate on a time clock and pump raw sludge from the primary clarifiers to the day tank. Sludge transfer pump No. 3 pumps scum from the primary clarifiers to he digestors. This is done manually, once a shift. Sludge transfer pump No. 4 pumps a mixture of thickener waste activated sludge, raw sludge, and scum from the day tank to the digestors.

Other conditions of operation are illustrated as follows:

Figure No.	Type of Operation
31	Sludge Transfer Pump No. 1 Out of Service
32	Sludge Transfer Pump No. 2 Out of Service
33	Sludge Transfer Pump No. 3 Out of Service
34	Sludge Transfer Pump No. 4 Out of Service
35	Use of Sludge Transfer Pump No. 2 to Clean Sludge Line from Primary Clarifier No. 2

It should be noted that it is possible to clean or unplug all sludge and scum lines by means similar to that illustrated by Figure 35.

Waste Activated Sludge Flotation Thickener. The purpose of the waste activated sludge flotation thickener is to thicken or dewater activated sludge, wasted from the aeration tanks. It is essential that this unit be operated efficiently, in order to insure that the centrifuges will function properly.

The equipment included in the flotation thickener include:

1. Feed Well
2. Collector Mechanism
3. Recirculation Pump
4. Flow Meter
5. Retention Tank
6. Reaeration Pump
7. Polymer Feed Pump & Mixing Tank

Figure 36 shows the flow patterns for the waste activated sludge flotation thickener under normal operation. Waste activated sludge flows into the feed well from the sludge flow division box. The flow rate of this incoming sludge is controlled by the recirculation sludge control center.

Polyelectrolyte is mixed with the sludge before it enters the feed well. The polymer is added to the sludge by means of a chemical feed

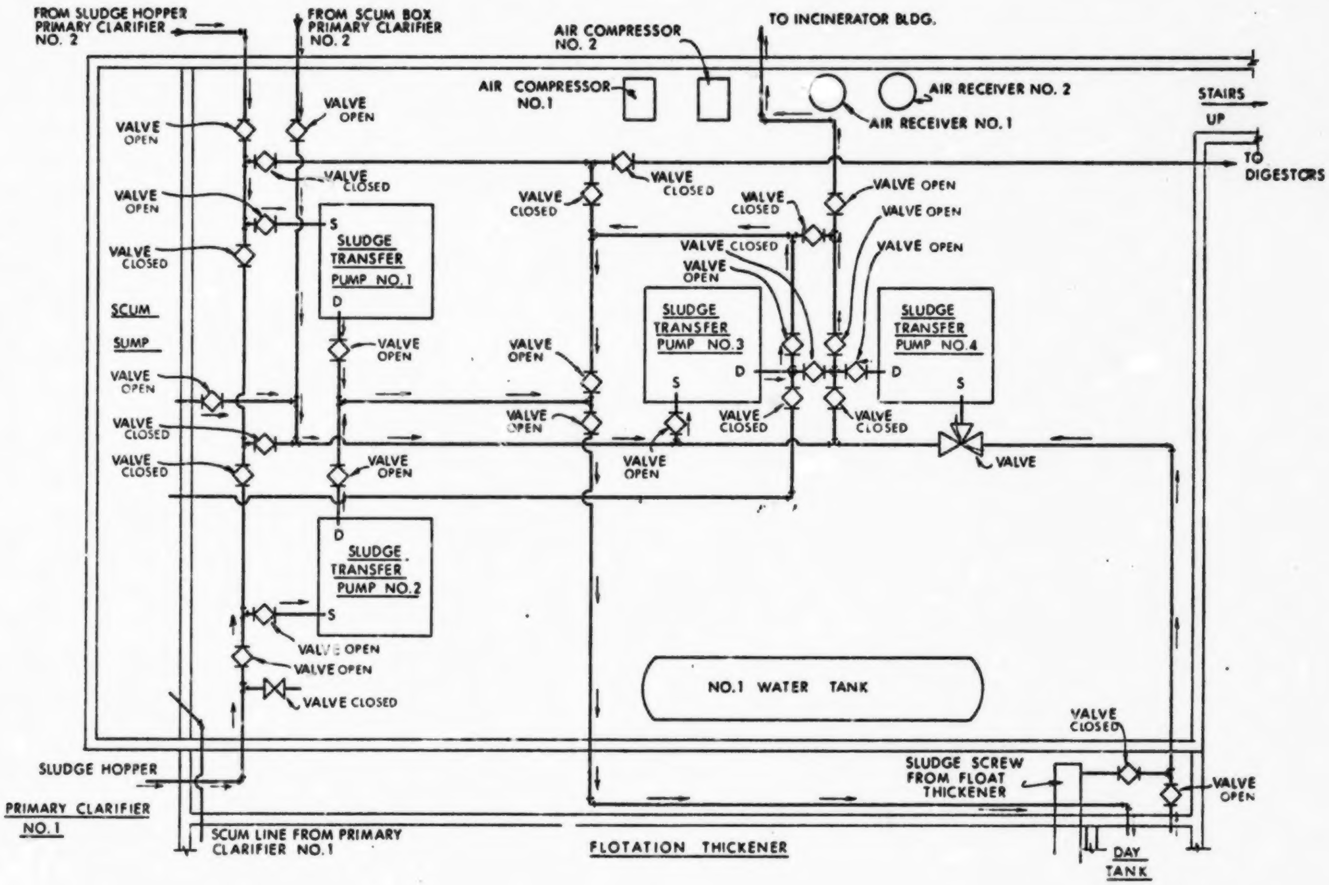


FIGURE- 29
PRIMARY SLUDGE AND WASTE ACTIVATED
SLUDGE PUMPS TO INCINERATOR BUILDING
NORMAL OPERATION

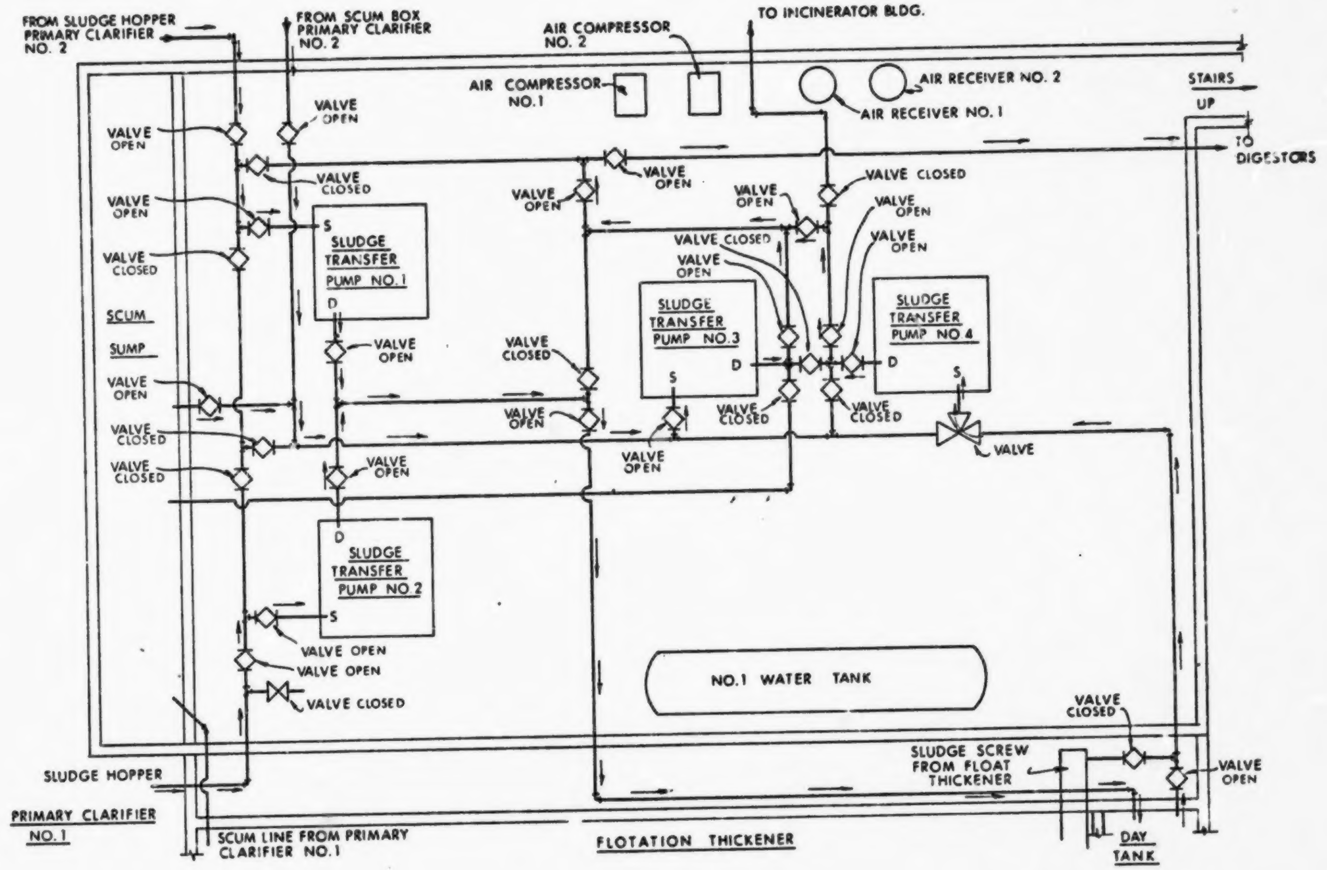

FROM SLUDGE HOPPER PRIMARY CLARIFIER NO. 2
FROM SCUM BOX PRIMARY CLARIFIER NO. 2
AIR COMPRESSOR NO. 2
TO INCINERATOR BLDG.
AIR COMPRESSOR NO. 1
AIR RECEIVER NO. 2
AIR RECEIVER NO. 1
STAIRS UP
TO DIGESTORS
VALVE OPEN
VALVE CLOSED
SLUDGE TRANSFER PUMP NO. 1
S
D
SCUM SUMP
SLUDGE TRANSFER PUMP NO. 2
SLUDGE TRANSFER PUMP NO. 3
SLUDGE TRANSFER PUMP NO 4
VALVE
NO. 1 WATER TANK
SLUDGE SCREW FROM FLOAT THICKENER
SLUDGE HOPPER
PRIMARY CLARIFIER NO. 1
SCUM LINE FROM PRIMARY CLARIFIER NO. 1
FLOTATION THICKENER
DAY TANK

FIGURE- 30
PRIMARY SLUDGE AND WASTE ACTIVATED SLUDGE PUMPS TO INCINERATOR BUILDING CENTRIFUGE OUT OF SERVICE

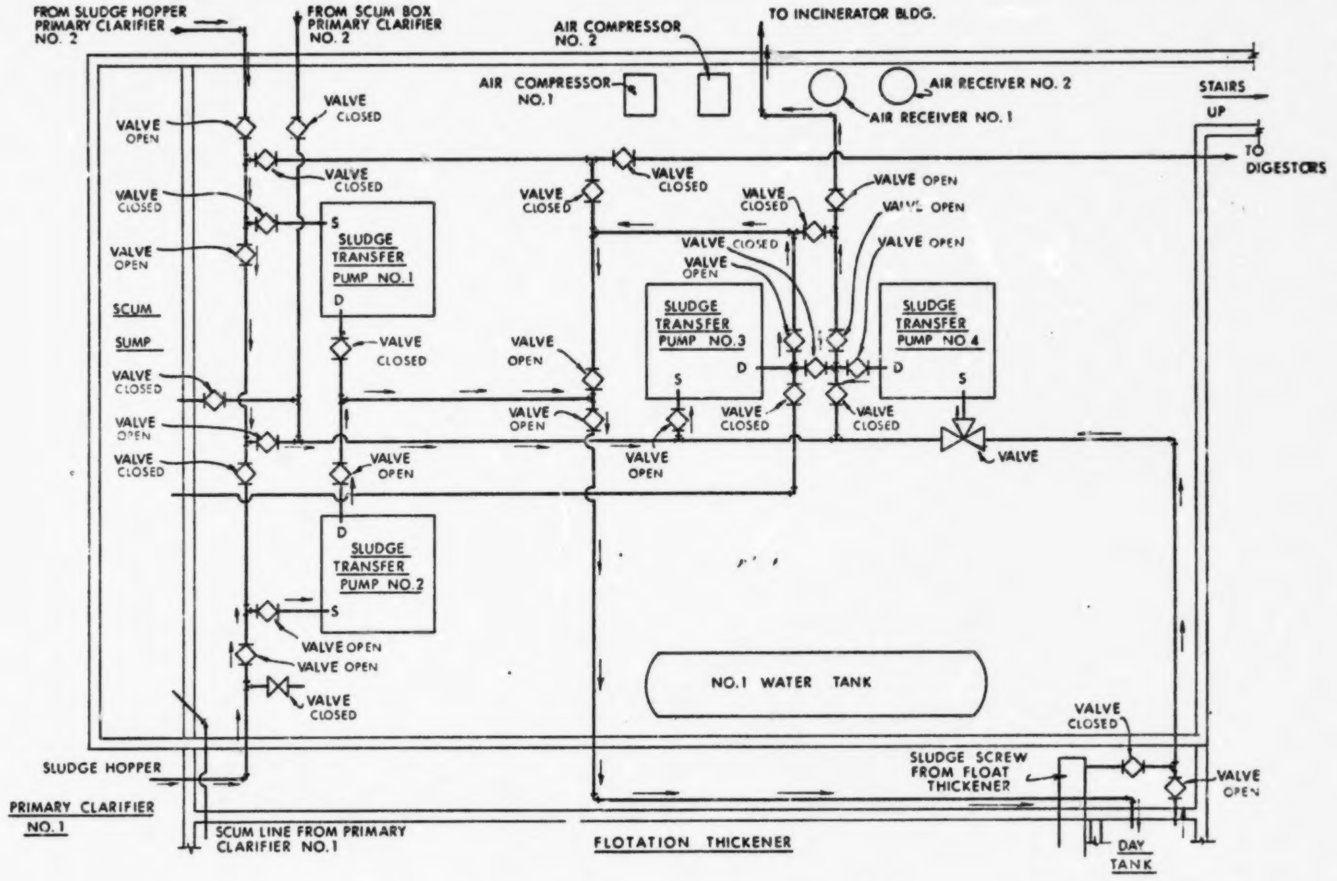


FIGURE- 31
PRIMARY SLUDGE AND WASTE ACTIVATED SLUDGE PUMPS TO INCINERATOR BUILDING
SLUDGE TRANSFER PUMP NO. 1
OUT OF SERVICE

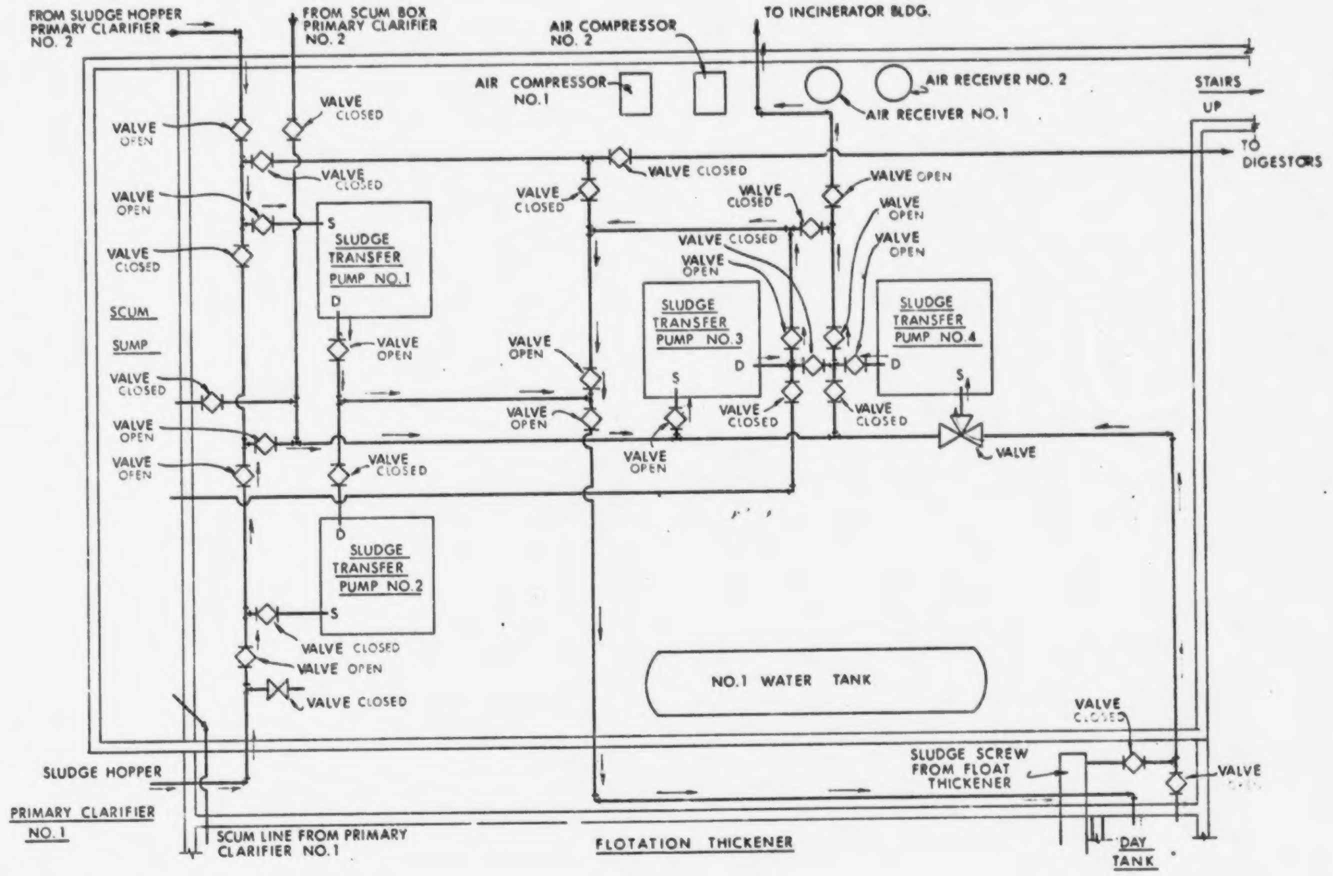


FIGURE- 32
PRIMARY SLUDGE AND WASTE ACTIVATED
SLUDGE PUMPS TO INCINERATOR BUILDING
SLUDGE TRANSFER PUMP NO 2
OUT OF SERVICE

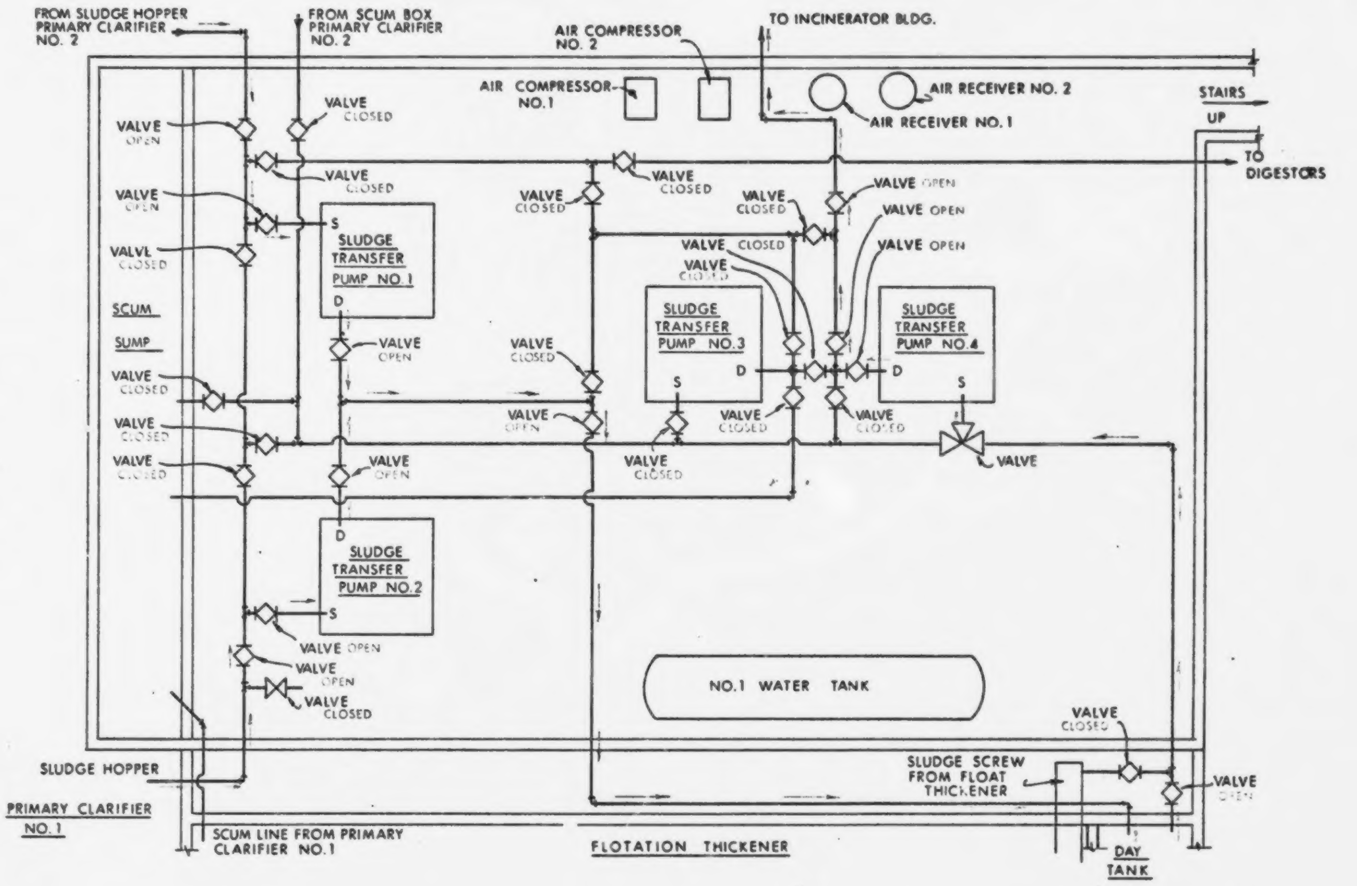


FIGURE- 33
PRIMARY SLUDGE AND WASTE ACTIVATED
SLUDGE PUMPS TO INCINERATOR BUILDING
SLUDGE TRANSFER PUMP NO. 3
OUT OF SERVICE

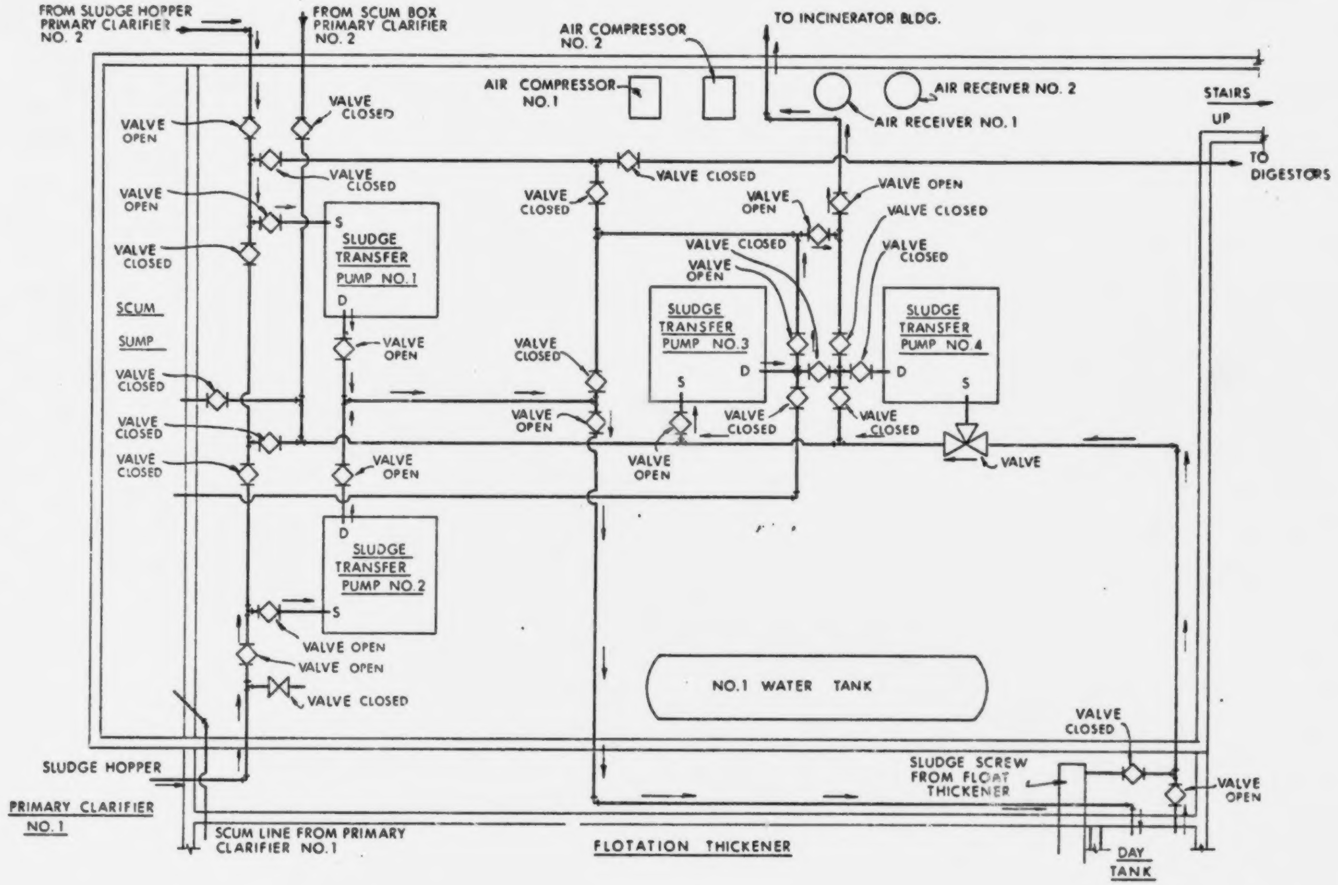


FIGURE- 34
PRIMARY SLUDGE AND WASTE ACTIVATED
SLUDGE PUMPS TO INCINERATOR BUILDING
SLUDGE TRANSFER PUMP NO. 4
OUT OF SERVICE

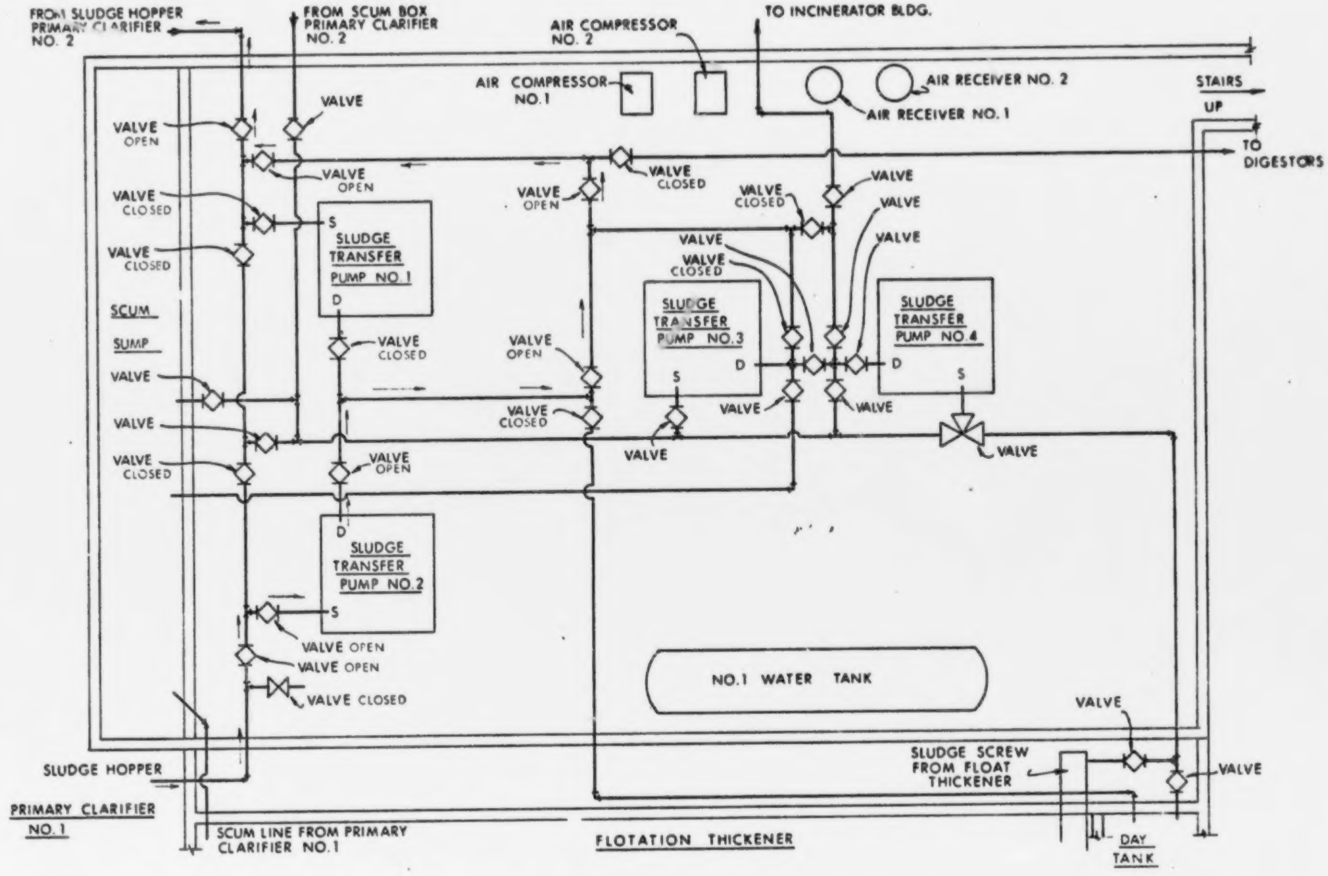
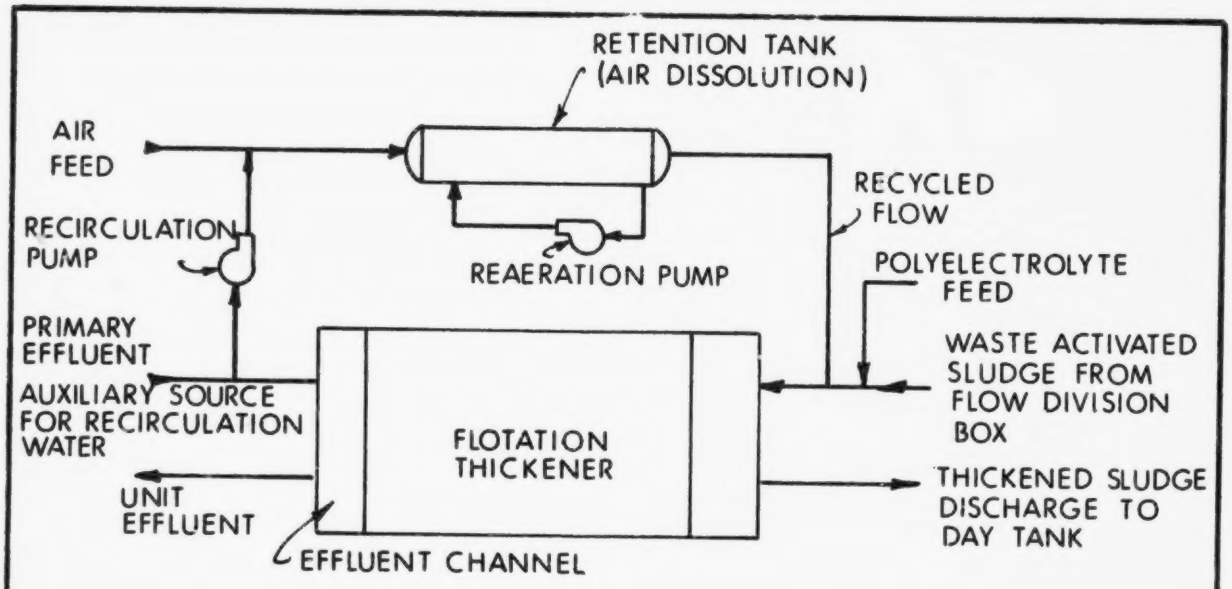
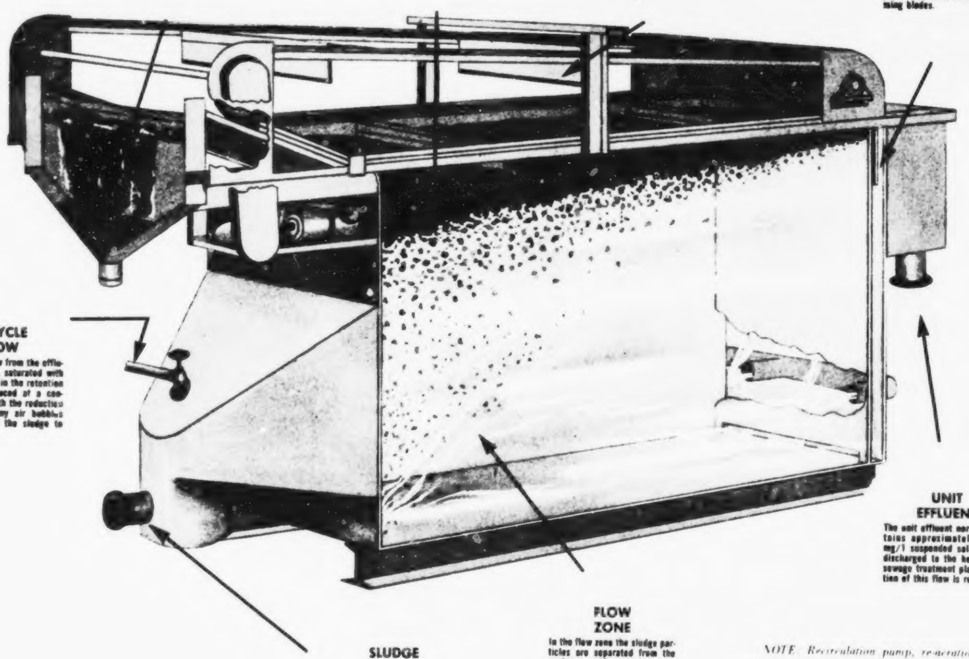


FIGURE- 3.5
PRIMARY SLUDGE AND WASTE ACTIVATED
SLUDGE PUMPS TO INCINERATOR BUILDING
USE OF SLUDGE TRANSFER PUMP NO. 2 TO CLEAN SLUDGE
LINE FROM PRIMARY CLARIFIER NO. 2



SCHEMATIC FLOW DIAGRAM



THICKENED SLUDGE DISCHARGE

This thickened sludge is discharged to a sump from which it is pumped to a vacuum filter or digester. Sludge concentrations of 4-6% can be expected with most sludges.

THICKENED SLUDGE ZONE

This thickened sludge creates a zone in the upper portion of the flotation unit and compacts and forces the surface of the sludge above the water level where it is removed by the sludge removal blades.

SLUDGE REMOVAL MECHANISM

The sludge removal mechanism consists of chains and skimming flights, sprockets and variable speed drive. The speed of the flights is varied to allow maximum concentration of sludge and minimum water carry-over.

ADJUSTABLE WEIR

This adjustable weir controls the liquid level within the flotation unit and the depth of penetration of the sludge skimming blades.

RECYCLE FLOW

The recycle flow from the effluent of the unit, saturated with air at 50-70 psi in the retention tank, is introduced at a controlled rate. With the reduction in pressure, tiny air bubbles form and float the sludge to the surface.

UNIT EFFLUENT

The unit effluent normally contains approximately 50-250 mg/1 suspended solids and is discharged to the head of the sewage treatment plant. A portion of this flow is recycled.

SLUDGE FEED

Waste sludge from the activated sludge system is conditioned with flotation aids and fed to the unit at a relatively constant rate.

FLOW ZONE

In the flow zone the sludge particles are separated from the water as they enter the thickened sludge zone. A properly operating flotation unit effects reliable and positive separation with minimum attention.

NOTE: Recirculation pump, re-aeration pump and retention tank are not shown. Also, the bottom sludge collectors or hoppers are not shown.

FIGURE - 36

WASTE ACTIVATED SLUDGE
FLOTATION THICKENER

7.8 Gals./In. 0.5% Solution

pump. The details of mixing the polymer and the quantities of polyelectrolyte to be added to the sludge are given later.

Water, supersaturated with air, is mixed with the incoming sludge. When the pressure is released from the supersaturated water, millions of small air bubbles are released, causing the solids in the waste activated sludge to float to the surface of the thickener. The collector mechanism skims the surface and pushes this floating sludge into the day tank. Any sludge which settles is pushed to a screw hopper located in the bottom of the tank by a chain-driven collector mechanism.

The resulting clear liquid flows over the effluent weir into the effluent channel. The recirculation pump pumps water from this channel into the retention tank. The quantity of water being recirculated is measured by the flowmeter.

The reaeration pump removes water from the retention tank, adds air to it, and then pumps it back into the tank. The resulting water, which is charged with air, is then sent to the feed well, as previously mentioned.

In the event that the effluent from the float thickener contains a large amount of solids, primary effluent may be used as a source of recirculation water by proper valving.

Digesters. In the completed 7-1/2 mgd plant, all biological sludge will be incinerated to sterile, insoluble ash. The sludge digesters then will be used primarily for emergency storage of biological sludge at times when the centrifuges are out of service. When only the incineration furnace is out of service but the centrifuges are operating, biological sludge either can be stored or dewatered and hauled to disposal, as desired.

A small quantity of active anaerobic sludge is to be kept in the digesters at all times so that sludge can be readily digested in the event the sludge dewatering or incineration equipment is inoperative.

Under normal operation, the water level in one digester should be maintained one (1) foot above the corbels in order to float the cover and prevent gas leakage. To keep the sludge active, it is recommended that approximately 6,000 gallons of 7 percent raw sludge be pumped to the digester each day (Figure 36A). This amount will raise the liquid level by one-half foot. The sludge pumping to the digester should be accomplished at three intervals during the day, once each shift.

Once daily, sludge shall be pumped from the digester back to the day tank in the primary in order to maintain the digester level. Figure 36B indicates the proper valve arrangements.

The volumes of sludge mentioned should be used as a guide only and should be adjusted in order to best maintain the chemical characteristics of the sludge (pH 6.8 to 8.0, volatile acids < 500 mg/l).

The second digester should be kept at a level above the corbels by filling it with No. 3 water. This is a safety measure. If any digester gas leaks through the gas piping into this digester, it can be trapped in the dome and pumped out.

The temperature of the active digester should be maintained at 95°F., and the water in the inactive digester should be kept above freezing.

In the event the sludge dewatering or incineration equipment cannot be used for a prolonged period, the second digester should be put into automatic series operation with the first digester. The piping schematic for this is shown in Figure 36C. The sludge circulation pump for the second digester is put on automatic control to pump from No. 1 to No. 2 each time the raw sludge pumps run.

Figure 36D indicates the alternate sludge circulation systems which should be maintained in the active digester at all times.

Figure 36E shows the valve arrangements necessary to draw sludge to the drying bed.

Secondary and Final Effluent Pump Stations. Figures 37 through 41 illustrate valve settings and pump use for various conditions of plant operation which affect the secondary and final effluent pump stations.

The secondary effluent pumps can pump chemical clarifier effluent or secondary effluent to the tertiary plant including water for backwashing the separation beds or filters. Under emergency conditions when the final effluent pumps are out of service, the secondary effluent pumps can be used to pump final effluent to the emergency 60 million gallon storage pond; under these conditions, the tertiary plant cannot be operated. The secondary effluent pumps cannot pump water to the

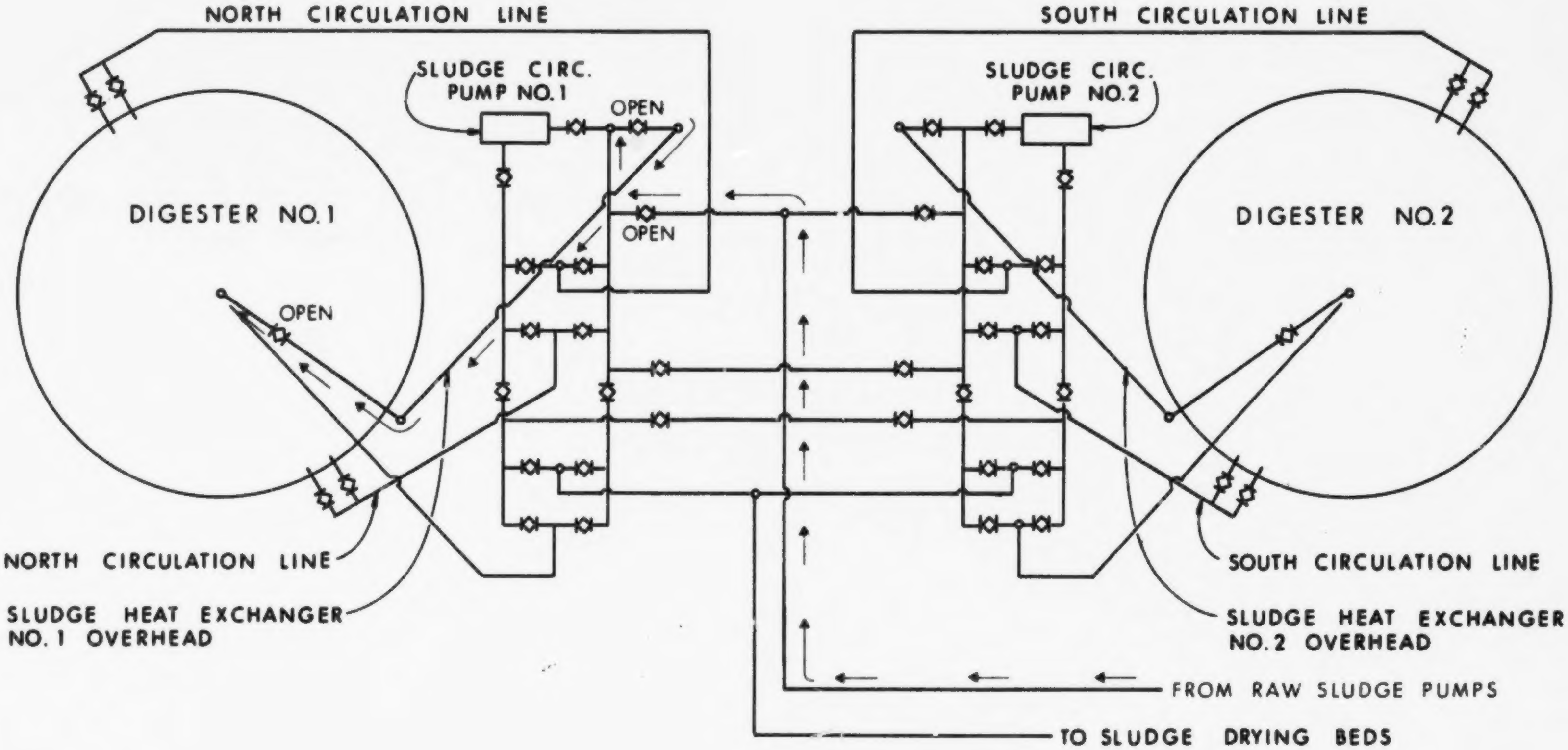


FIGURE 36A
DIGESTERS

TRANSFER BY RAW SLUDGE PUMPS TO DIGESTERS

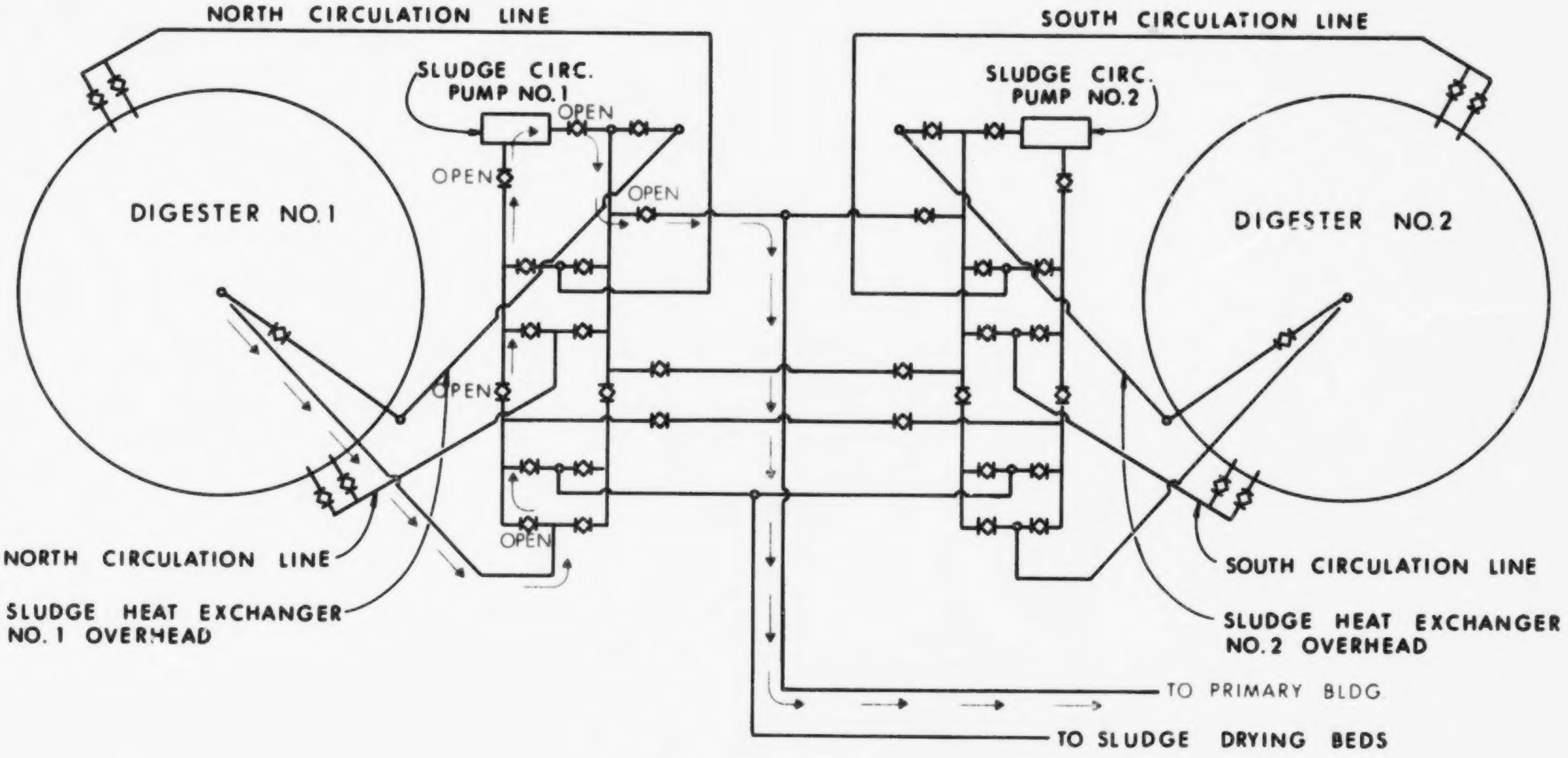


FIGURE 36B
DIGESTERS
SLUDGE TRANSFER FROM DIGESTERS
TO DEWATERING SYSTEM

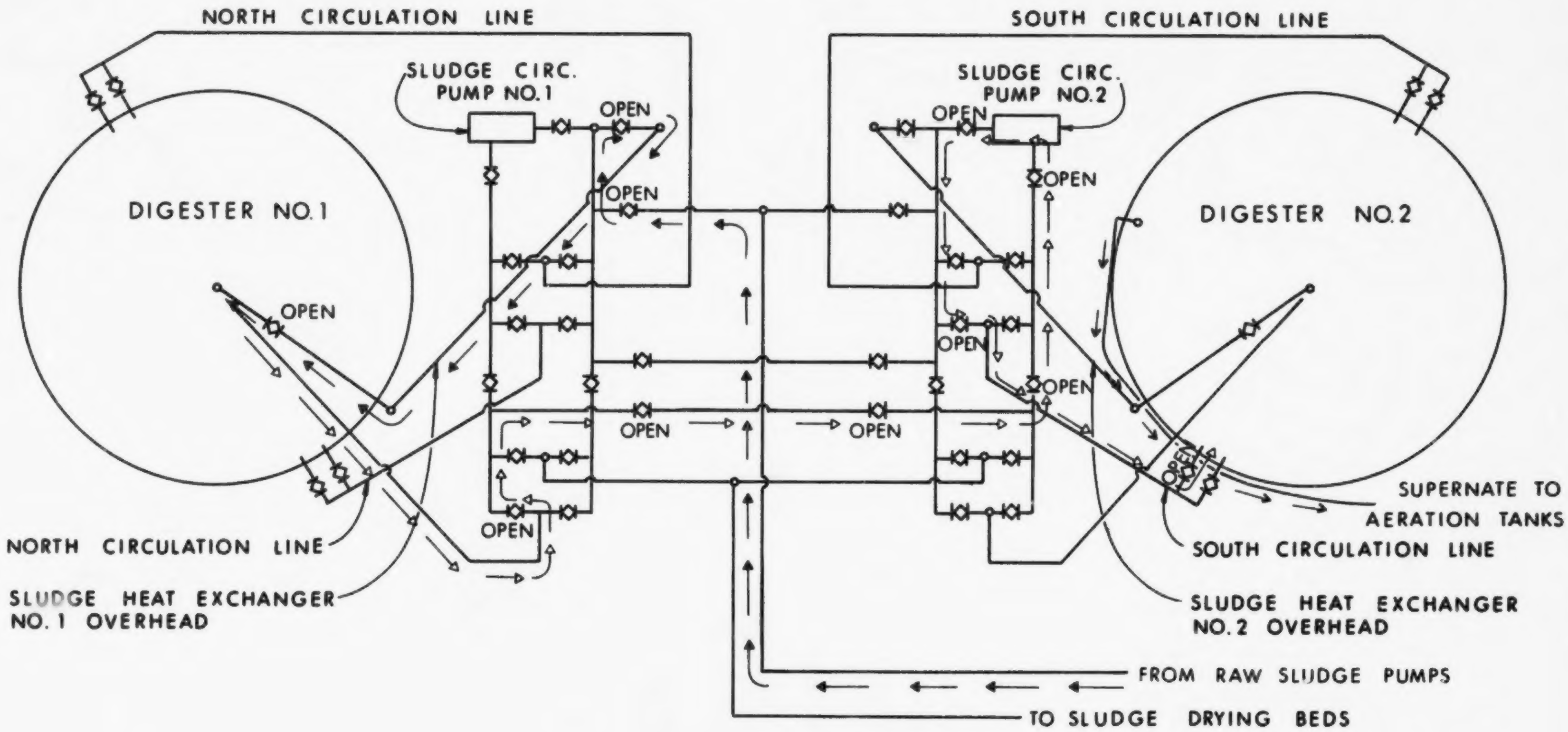


FIGURE 36C
DIGESTERS
NORMAL SERIES DIGESTER OPERATION
WITH AUTOMATIC TRANSFER

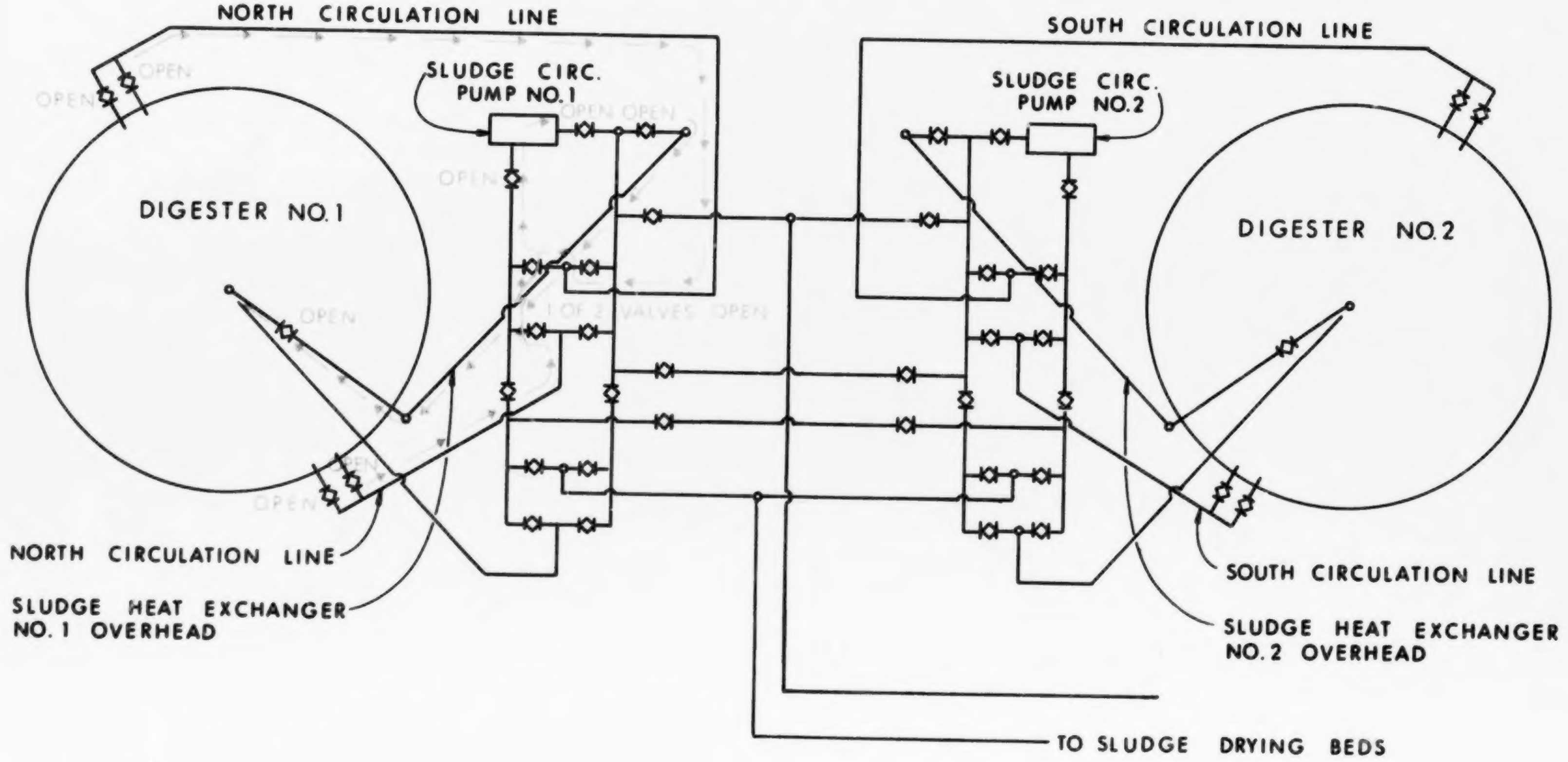


FIGURE 36.0
DIGESTERS
SLUDGE CIRCULATION SYSTEM

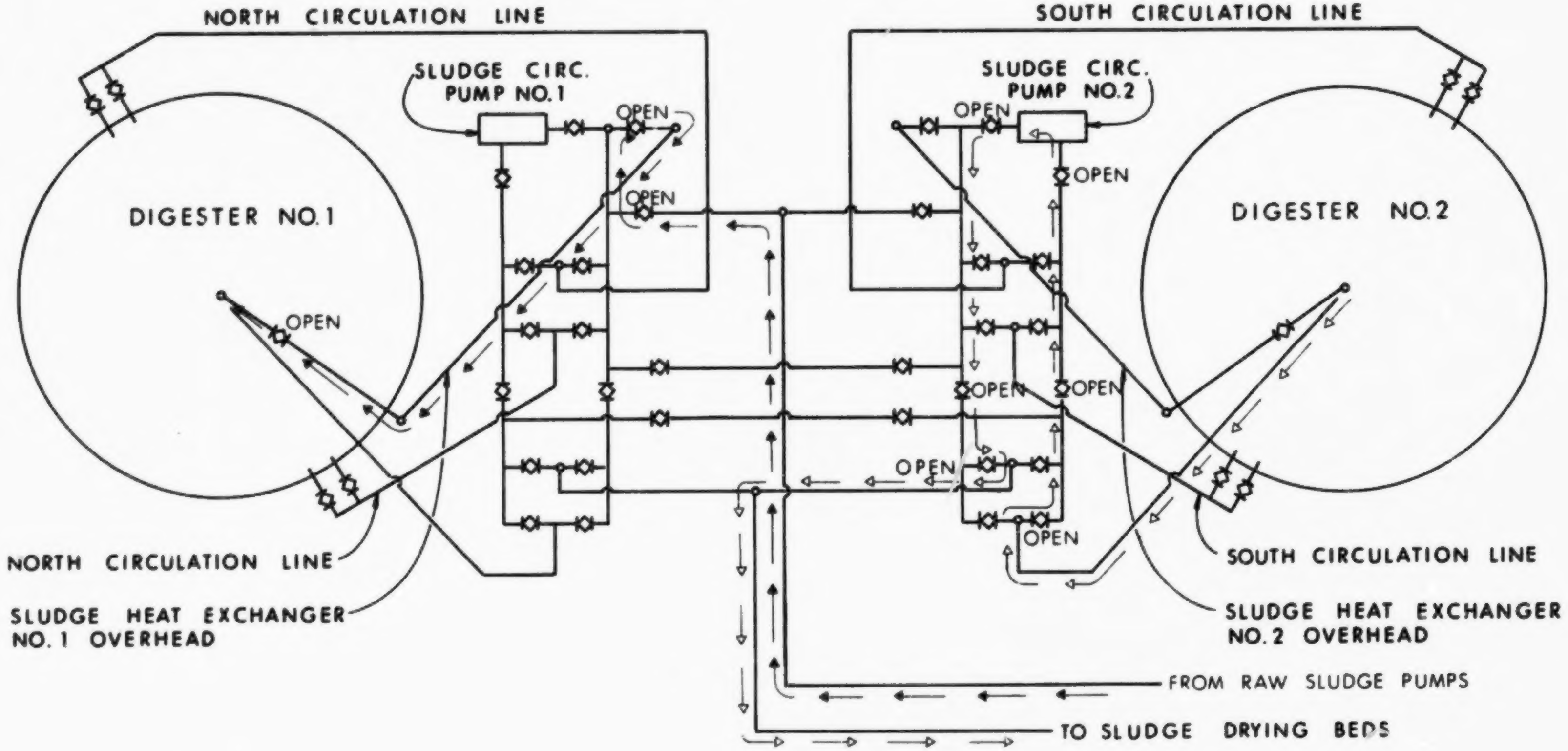


FIGURE 36E
DIGESTERS
SLUDGE WITHDRAWAL TO DRYING BEDS

← SLUDGE FEED
⇽ SLUDGE WITHDRAWAL

Luther Pass Pump Station because of the higher discharge head required for this service which exceeds the capacity of these pumps.

The final effluent pumps can pump final effluent either to the Luther Pass Pump Station or, in an emergency, to the 60 million gallon storage pond or spray field.

Plant service water (No. 3 water) normally is taken through a pressure reducing valve from the discharge line to the Luther Pass Pump Station. There is one million gallons of water stored in a reservoir at the upper end of the Luther Pass pipeline, so that adequate pressure may be available to supply plant service water (No. 3 water) even though the final effluent pumps are out of service for a short time. However, if the final effluent pumps are out of service for a long period of time and the one mg reservoir is empty, then it will be necessary to supply No. 3 water by means of the three No. 3 water pumps in the secondary and final effluent pump station.

Figure 37 shows pump operation and valve settings for normal operation. The secondary effluent pumps are discharging to the tertiary plant and the bypass to the emergency storage pond is closed. The final effluent pumps are discharging to the Luther Pass Pump Station, and No. 3 water is being supplied from the Luther Pass pipeline back through the pressure reducing valve. The No. 3 water pumps are off.

Figure 38 is similar to the normal condition just described, except that the No. 3 water supply line is out of service and the No. 3 water pumps are in use.

Figure 39 shows pump station operation when the final effluent pumps are out of service. The secondary effluent pumps are discharging to the emergency 60 mg storage pond. The tertiary plant is out of service, and the No. 3 water pumps are on.

Figure 40 shows pumps station operation when the quality of final effluent being produced by the treatment plant is not good enough for export. The tertiary plant may be either on or off, probably off, under these conditions. The final effluent pumps are discharging into the 60 mg holding pond, and the No. 3 water pumps are on.

Figure 41 illustrates a rather unusual situation, that is, pumping from the 60 mg storage pond to the Luther Pass Pump Station. This would be done only if the quality of water stored in the emergency pond is good enough for export. By regulating the rate of flow back from the 60 mg emergency pond into the final effluent wet well, it is possible to keep the plant in normal operation. Since the final effluent is being exported under these conditions, the tertiary plant would be in operation. The No. 3 water pumps are off.

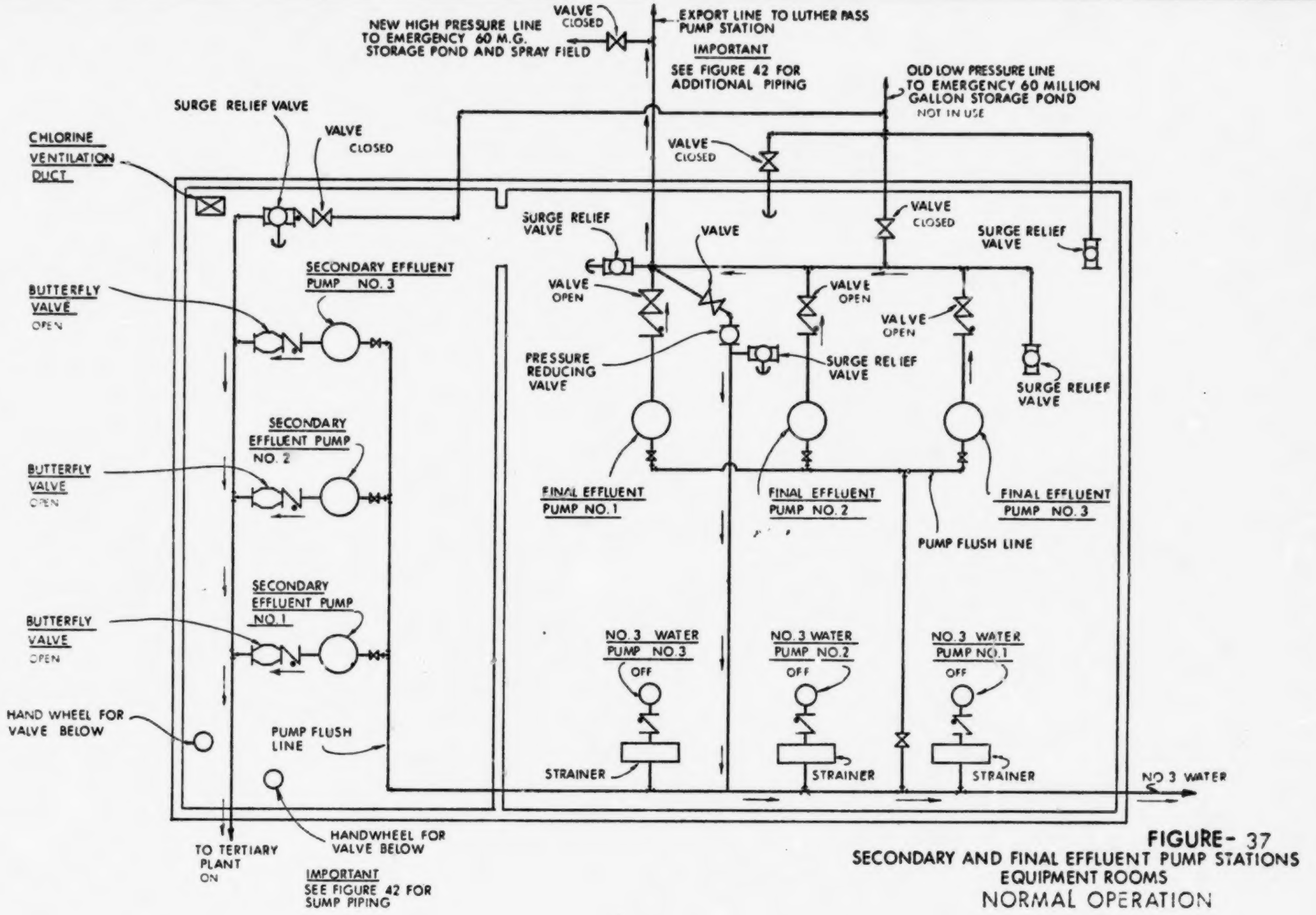

NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. STORAGE POND AND SPRAY FIELD
VALVE CLOSED
EXPORT LINE TO LUTHER PASS PUMP STATION
IMPORTANT
SEE FIGURE 42 FOR ADDITIONAL PIPING
OLD LOW PRESSURE LINE TO EMERGENCY 60 MILLION GALLON STORAGE POND
NOT IN USE
SURGE RELIEF VALVE
VALVE CLOSED
CHLORINE VENTILATION DUCT
VALVE CLOSED
SURGE RELIEF VALVE
VALVE
VALVE CLOSED
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 3
BUTTERFLY VALVE OPEN
VALVE OPEN
VALVE OPEN
VALVE OPEN
PRESSURE REDUCING VALVE
SURGE RELIEF VALVE
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 2
BUTTERFLY VALVE OPEN
FINAL EFFLUENT PUMP NO. 1
FINAL EFFLUENT PUMP NO. 2
FINAL EFFLUENT PUMP NO. 3
PUMP FLUSH LINE
SECONDARY EFFLUENT PUMP NO. 1
BUTTERFLY VALVE OPEN
NO. 3 WATER PUMP NO. 3
OFF
NO. 3 WATER PUMP NO. 2
OFF
NO. 3 WATER PUMP NO. 1
OFF
HAND WHEEL FOR VALVE BELOW
PUMP FLUSH LINE
STRAINER
STRAINER
STRAINER
NO 3 WATER
TO TERTIARY PLANT ON
HANDWHEEL FOR VALVE BELOW
IMPORTANT
SEE FIGURE 42 FOR SUMP PIPING

FIGURE- 37
SECONDARY AND FINAL EFFLUENT PUMP STATIONS
EQUIPMENT ROOMS
NORMAL OPERATION

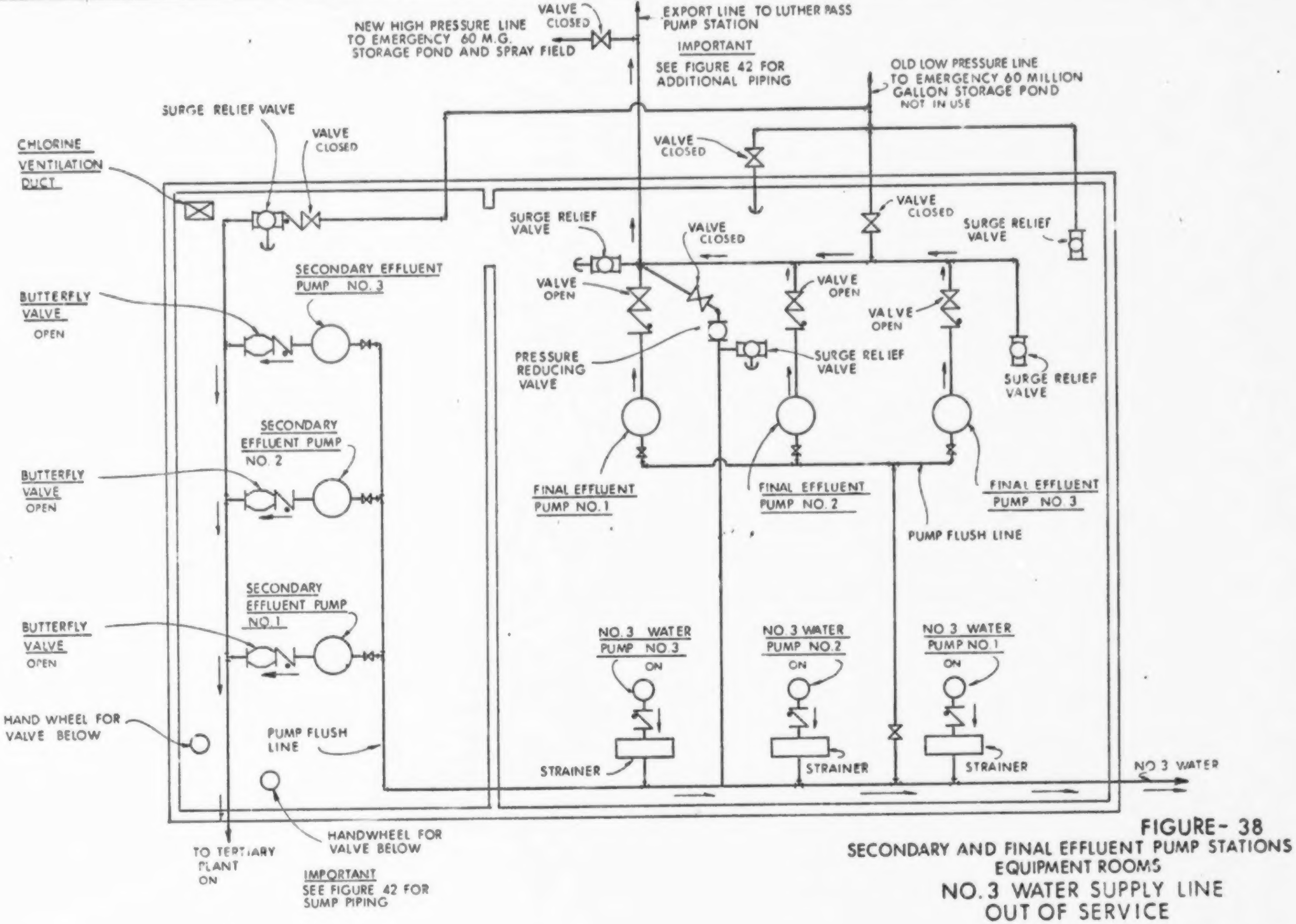

NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. STORAGE POND AND SPRAY FIELD
VALVE CLOSED
EXPORT LINE TO LUTHER PASS PUMP STATION
IMPORTANT
SEE FIGURE 42 FOR ADDITIONAL PIPING
OLD LOW PRESSURE LINE TO EMERGENCY 60 MILLION GALLON STORAGE POND NOT IN USE
SURGE RELIEF VALVE
VALVE CLOSED
VALVE CLOSED
CHLORINE VENTILATION DUCT
VALVE CLOSED
SURGE RELIEF VALVE
SURGE RELIEF VALVE
VALVE CLOSED
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 3
BUTTERFLY VALVE OPEN
VALVE OPEN
VALVE OPEN
VALVE OPEN
PRESSURE REDUCING VALVE
SURGE RELIEF VALVE
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 2
BUTTERFLY VALVE OPEN
FINAL EFFLUENT PUMP NO. 1
FINAL EFFLUENT PUMP NO. 2
FINAL EFFLUENT PUMP NO. 3
PUMP FLUSH LINE
SECONDARY EFFLUENT PUMP NO. 1
BUTTERFLY VALVE OPEN
NO. 3 WATER PUMP NO. 3 ON
NO 3 WATER PUMP NO. 2 ON
NO 3 WATER PUMP NO. 1 ON
HAND WHEEL FOR VALVE BELOW
PUMP FLUSH LINE
STRAINER
STRAINER
STRAINER
NO 3 WATER
TO TERTIARY PLANT ON
HANDWHEEL FOR VALVE BELOW
IMPORTANT
SEE FIGURE 42 FOR SUMP PIPING

FIGURE- 38
SECONDARY AND FINAL EFFLUENT PUMP STATIONS
EQUIPMENT ROOMS
NO. 3 WATER SUPPLY LINE
OUT OF SERVICE

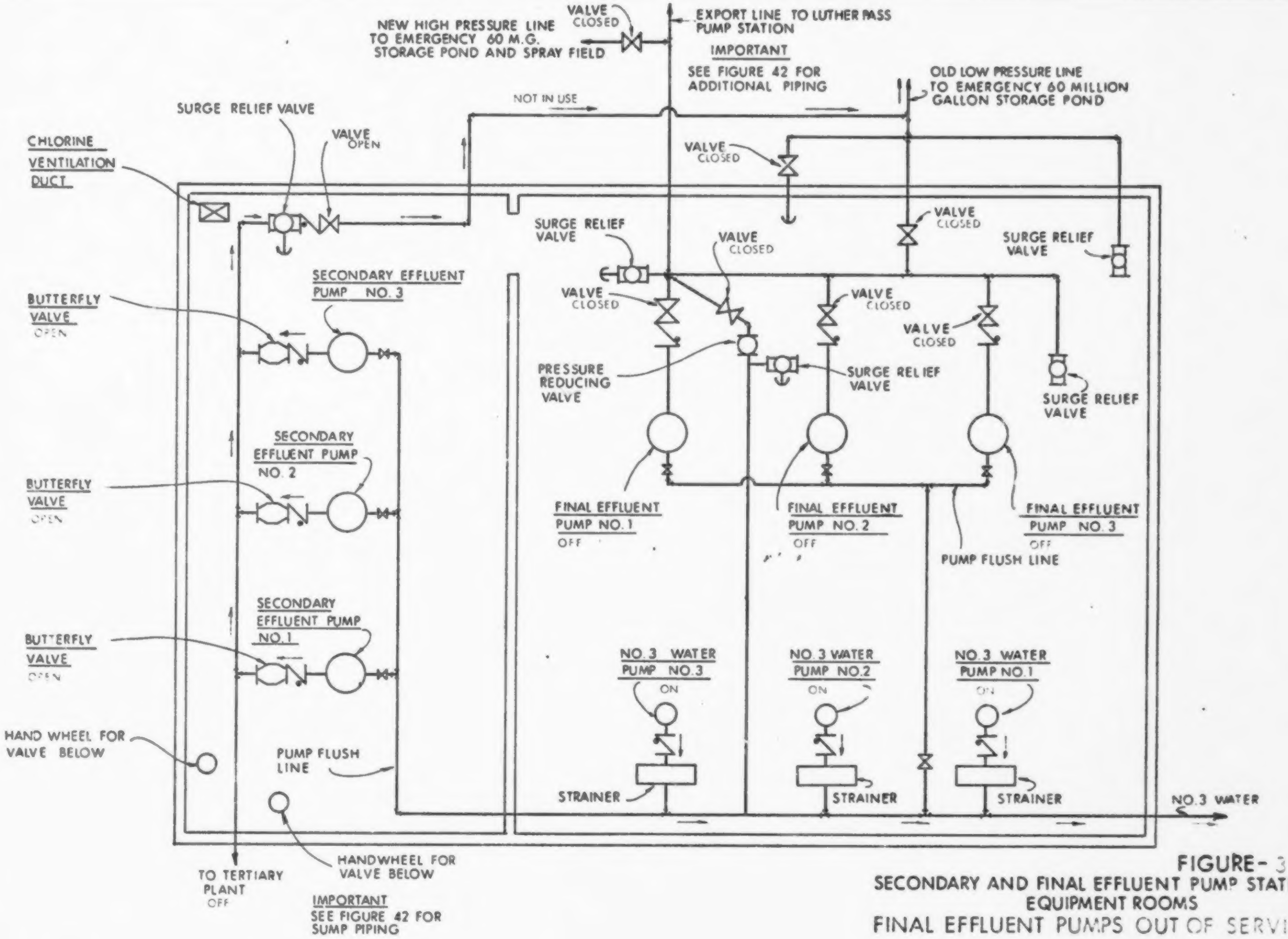

NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. STORAGE POND AND SPRAY FIELD
VALVE CLOSED
EXPORT LINE TO LUTHER PASS PUMP STATION
IMPORTANT
SEE FIGURE 42 FOR ADDITIONAL PIPING
OLD LOW PRESSURE LINE TO EMERGENCY 60 MILLION GALLON STORAGE POND
NOT IN USE
SURGE RELIEF VALVE
VALVE OPEN
CHLORINE VENTILATION DUCT
VALVE CLOSED
SURGE RELIEF VALVE
VALVE CLOSED
VALVE CLOSED
VALVE CLOSED
VALVE CLOSED
VALVE CLOSED
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 3
BUTTERFLY VALVE OPEN
PRESSURE REDUCING VALVE
SURGE RELIEF VALVE
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 2
BUTTERFLY VALVE OPEN
FINAL EFFLUENT PUMP NO. 1 OFF
FINAL EFFLUENT PUMP NO. 2 OFF
FINAL EFFLUENT PUMP NO. 3 OFF
PUMP FLUSH LINE
SECONDARY EFFLUENT PUMP NO. 1
BUTTERFLY VALVE OPEN
NO. 3 WATER PUMP NO. 3 ON
NO. 3 WATER PUMP NO. 2 ON
NO. 3 WATER PUMP NO. 1 ON
HAND WHEEL FOR VALVE BELOW
PUMP FLUSH LINE
STRAINER
STRAINER
STRAINER
NO. 3 WATER
TO TERTIARY PLANT OFF
HANDWHEEL FOR VALVE BELOW
IMPORTANT
SEE FIGURE 42 FOR SUMP PIPING

FIGURE- 39
SECONDARY AND FINAL EFFLUENT PUMP STATIONS
EQUIPMENT ROOMS
FINAL EFFLUENT PUMPS OUT OF SERVICE

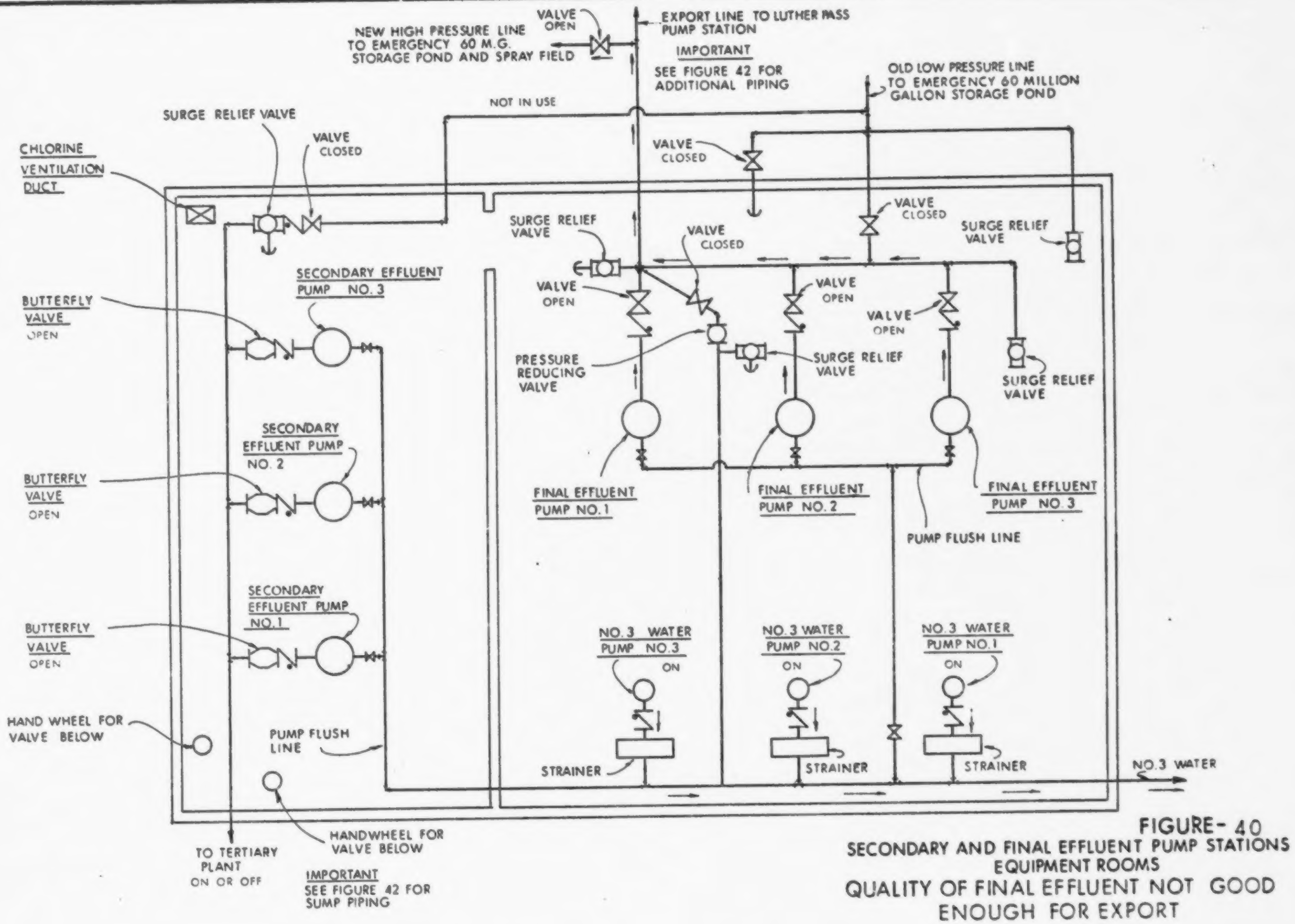

VALVE OPEN
NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. STORAGE POND AND SPRAY FIELD
EXPORT LINE TO LUTHER PASS PUMP STATION
IMPORTANT
SEE FIGURE 42 FOR ADDITIONAL PIPING
OLD LOW PRESSURE LINE TO EMERGENCY 60 MILLION GALLON STORAGE POND
NOT IN USE
SURGE RELIEF VALVE
VALVE CLOSED
CHLORINE VENTILATION DUCT
VALVE CLOSED
VALVE CLOSED
SURGE RELIEF VALVE
VALVE CLOSED
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 3
BUTTERFLY VALVE OPEN
VALVE OPEN
VALVE OPEN
VALVE OPEN
PRESSURE REDUCING VALVE
SURGE RELIEF VALVE
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 2
BUTTERFLY VALVE OPEN
FINAL EFFLUENT PUMP NO. 1
FINAL EFFLUENT PUMP NO. 2
FINAL EFFLUENT PUMP NO. 3
PUMP FLUSH LINE
SECONDARY EFFLUENT PUMP NO. 1
BUTTERFLY VALVE OPEN
NO. 3 WATER PUMP NO. 3 ON
NO. 3 WATER PUMP NO. 2 ON
NO. 3 WATER PUMP NO. 1 ON
HAND WHEEL FOR VALVE BELOW
PUMP FLUSH LINE
STRAINER
STRAINER
STRAINER
NO. 3 WATER
TO TERTIARY PLANT ON OR OFF
HANDWHEEL FOR VALVE BELOW
IMPORTANT
SEE FIGURE 42 FOR SUMP PIPING

FIGURE- 40
SECONDARY AND FINAL EFFLUENT PUMP STATIONS
EQUIPMENT ROOMS
QUALITY OF FINAL EFFLUENT NOT GOOD
ENOUGH FOR EXPORT

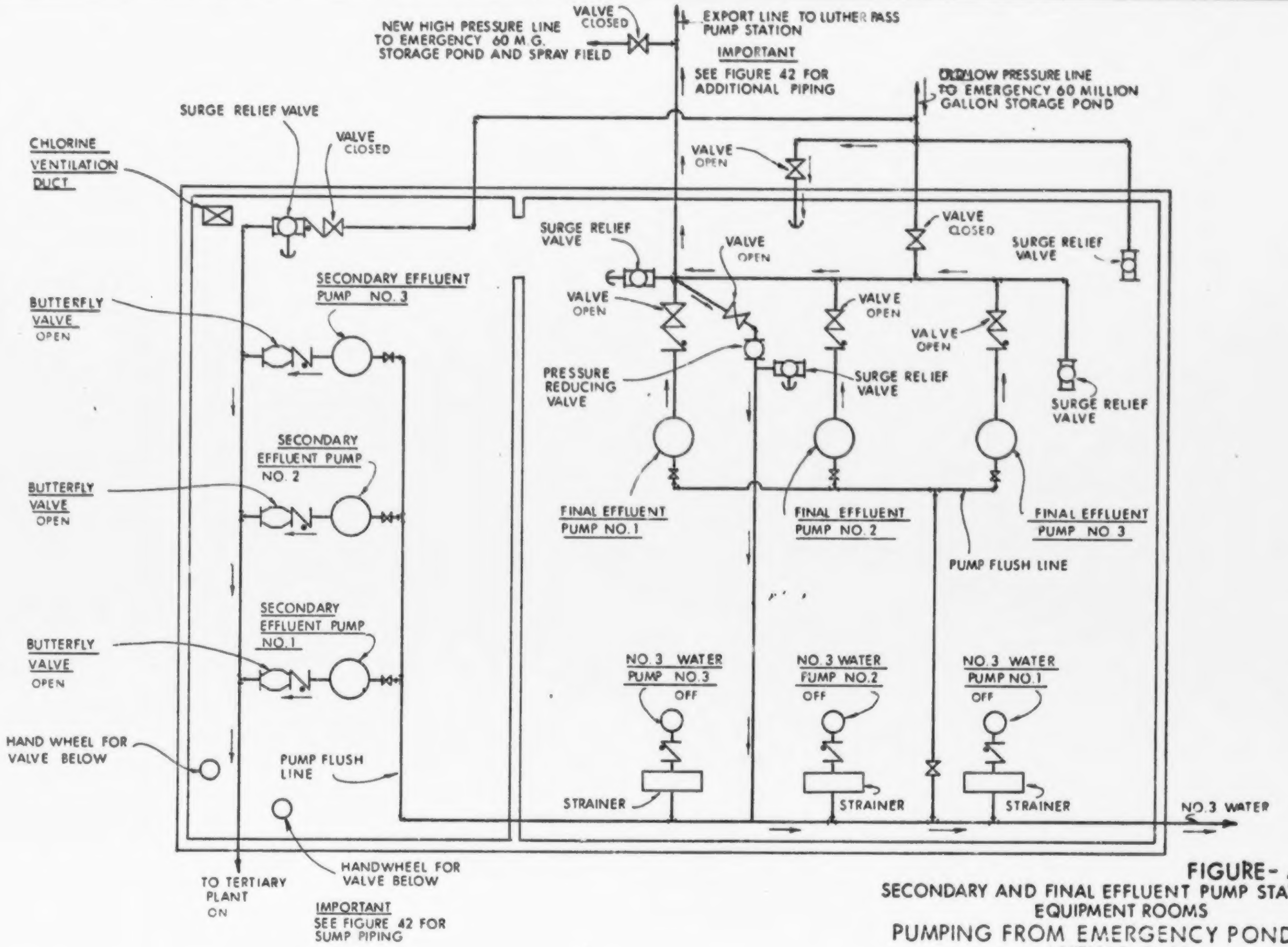

NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. STORAGE POND AND SPRAY FIELD
VALVE CLOSED
EXPORT LINE TO LUTHER PASS PUMP STATION
IMPORTANT
SEE FIGURE 42 FOR ADDITIONAL PIPING
OLD LOW PRESSURE LINE TO EMERGENCY 60 MILLION GALLON STORAGE POND
SURGE RELIEF VALVE
VALVE CLOSED
CHLORINE VENTILATION DUCT
VALVE OPEN
VALVE CLOSED
SURGE RELIEF VALVE
SURGE RELIEF VALVE
VALVE OPEN
SECONDARY EFFLUENT PUMP NO. 3
BUTTERFLY VALVE OPEN
VALVE OPEN
VALVE OPEN
VALVE OPEN
PRESSURE REDUCING VALVE
SURGE RELIEF VALVE
SURGE RELIEF VALVE
SECONDARY EFFLUENT PUMP NO. 2
BUTTERFLY VALVE OPEN
FINAL EFFLUENT PUMP NO. 1
FINAL EFFLUENT PUMP NO. 2
FINAL EFFLUENT PUMP NO 3
PUMP FLUSH LINE
SECONDARY EFFLUENT PUMP NO. 1
BUTTERFLY VALVE OPEN
NO. 3 WATER PUMP NO. 3 OFF
NO. 3 WATER PUMP NO. 2 OFF
NO. 3 WATER PUMP NO. 1 OFF
HAND WHEEL FOR VALVE BELOW
PUMP FLUSH LINE
STRAINER
STRAINER
STRAINER
NO. 3 WATER
TO TERTIARY PLANT ON
HANDWHEEL FOR VALVE BELOW
IMPORTANT
SEE FIGURE 42 FOR SUMP PIPING

FIGURE- 41
SECONDARY AND FINAL EFFLUENT PUMP STATIONS
EQUIPMENT ROOMS
PUMPING FROM EMERGENCY POND TO LUTHER PASS

Ballast Ponds. The ballast ponds serve two primary purposes: (1) they provide storage of chemical clarifier effluent for backwashing of the separation beds, and (2) they provide space for storage of peak waste water flows which allows the tertiary plants and final effluent pumps to operate at lower and more uniform rates. They may serve a third purpose on occasions when water from the decant tank is turbid, by providing settling time for clarification of the decant water.

There are two ballast ponds, which normally would contain chemical clarifier effluent, and which would be operated in series and connected to the wet well for the secondary effluent pumps. It is possible to operate the plant with either one of the ballast ponds out of service. In addition, it is also possible to operate pond No. 2 containing chemical clarifier effluent and connected to the wet well for the secondary effluent pumps at the same time that pond No. 1 containing final effluent is connected to the wet well for final effluent.

The method of operating the decant tank for filter backwash water may have an effect on selection of the best method of pond operation. In any event, *sludge* from the decant tank will be discharged from the bottom of the tank through the sludge valve to the rapid mix, flocculator, and chemical clarifier. Optionally, *all* of the contents of the decant tank may follow the same path. Normally, however, the water in the decant tank skimmed from the surface of the tank through the float arm would flow directly into the ballast ponds. At times when the decanted liquid is not clear, it is advantageous for the ballast ponds to be operated in series as settling basins in order not to return solids from the decant tank back to the filters.

Figure 42 shows the ballast ponds in normal operation receiving chemical clarifier effluent and decanted backwash water into pond No. 2 from whence it then flows to pond No. 1 and then to the wet well for the secondary effluent pumps.

Figure 43 illustrates the flow pattern and valve settings with pond No. 1 out of service.

Figure 44 shows plant operation with pond No. 2 out of service.

Figure 45 shows the routing of flow when the tertiary plant is out of service (including the secondary effluent pump station also out of service).

Figure 46 shows pond No. 2 in service with chemical clarifier effluent and pond No. 1 in service with final effluent. With this arrangement it is mandatory to discharge all of the *water and sludge* from the decant tank through the bottom sludge valve to either the primary tank or to the rapid mix. Otherwise, the decanted water would be discharged in the final effluent with an adverse effect on final effluent quality.

Figure 47 shows a method for returning partially treated waste water stored in the emergency 60 mg pond for tertiary treatment along with chemical clarifier effluent for subsequent export to Luther Pass.

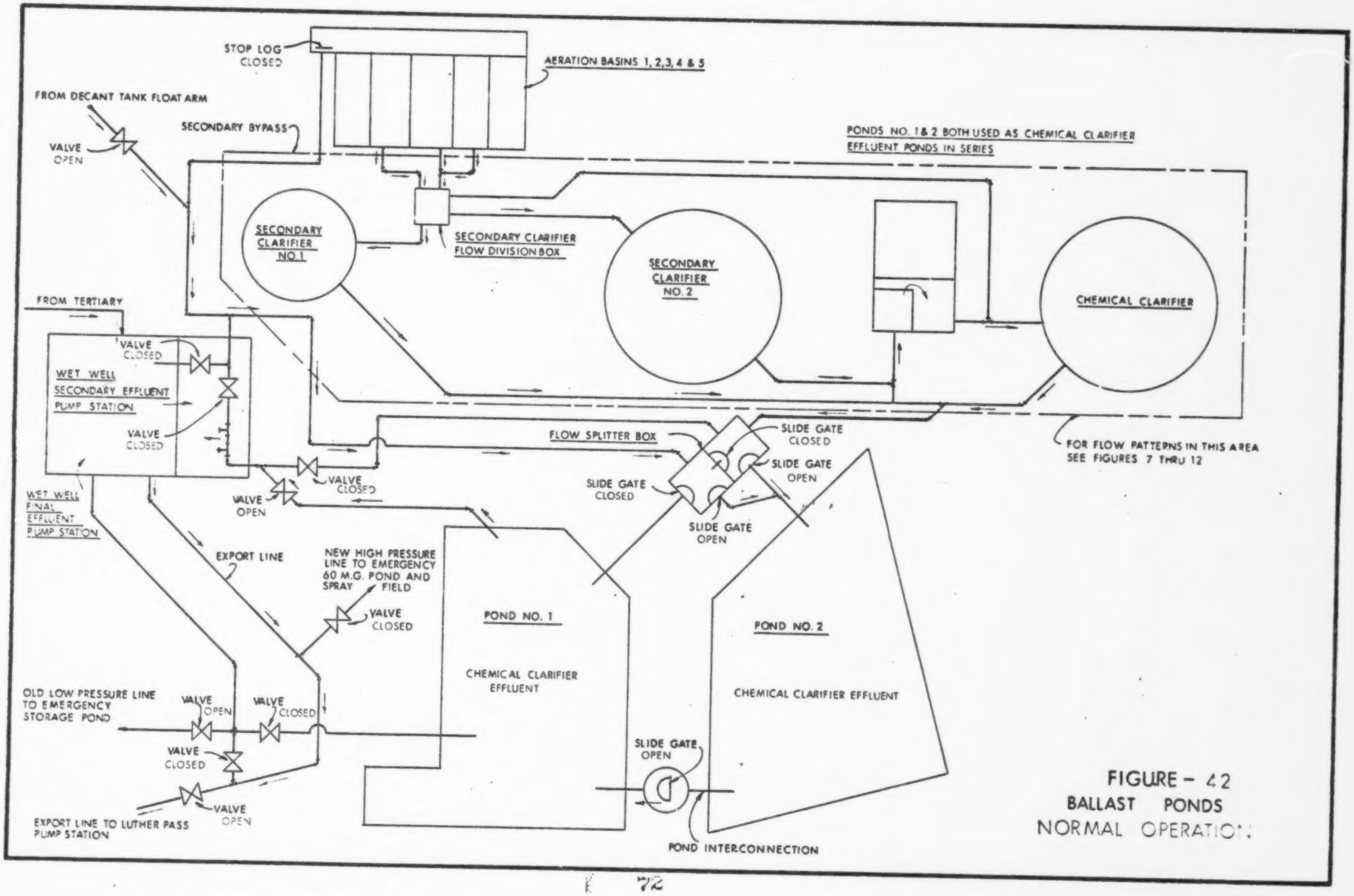

STOP LOG
CLOSED
AERATION BASINS 1, 2, 3, 4 & 5
FROM DECANT TANK FLOAT ARM
VALVE
OPEN
SECONDARY BYPASS
PONDS NO. 1 & 2 BOTH USED AS CHEMICAL CLARIFIER EFFLUENT PONDS IN SERIES
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER FLOW DIVISION BOX
SECONDARY CLARIFIER NO. 2
CHEMICAL CLARIFIER
FROM TERTIARY
VALVE
CLOSED
WET WELL
SECONDARY EFFLUENT
PUMP STATION
VALVE
CLOSED
FLOW SPLITTER BOX
SLIDE GATE
CLOSED
SLIDE GATE
OPEN
SLIDE GATE
CLOSED
SLIDE GATE
OPEN
FOR FLOW PATTERNS IN THIS AREA SEE FIGURES 7 THRU 12
VALVE
CLOSED
VALVE
OPEN
WET WELL
FINAL
EFFLUENT
PUMP STATION
EXPORT LINE
NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. POND AND SPRAY FIELD
VALVE
CLOSED
POND NO. 1
CHEMICAL CLARIFIER EFFLUENT
POND NO. 2
CHEMICAL CLARIFIER EFFLUENT
OLD LOW PRESSURE LINE TO EMERGENCY STORAGE POND
VALVE
OPEN
VALVE
CLOSED
VALVE
CLOSED
SLIDE GATE
OPEN
VALVE
OPEN
EXPORT LINE TO LUTHER PASS PUMP STATION
POND INTERCONNECTION

FIGURE - 42
BALLAST PONDS
NORMAL OPERATION

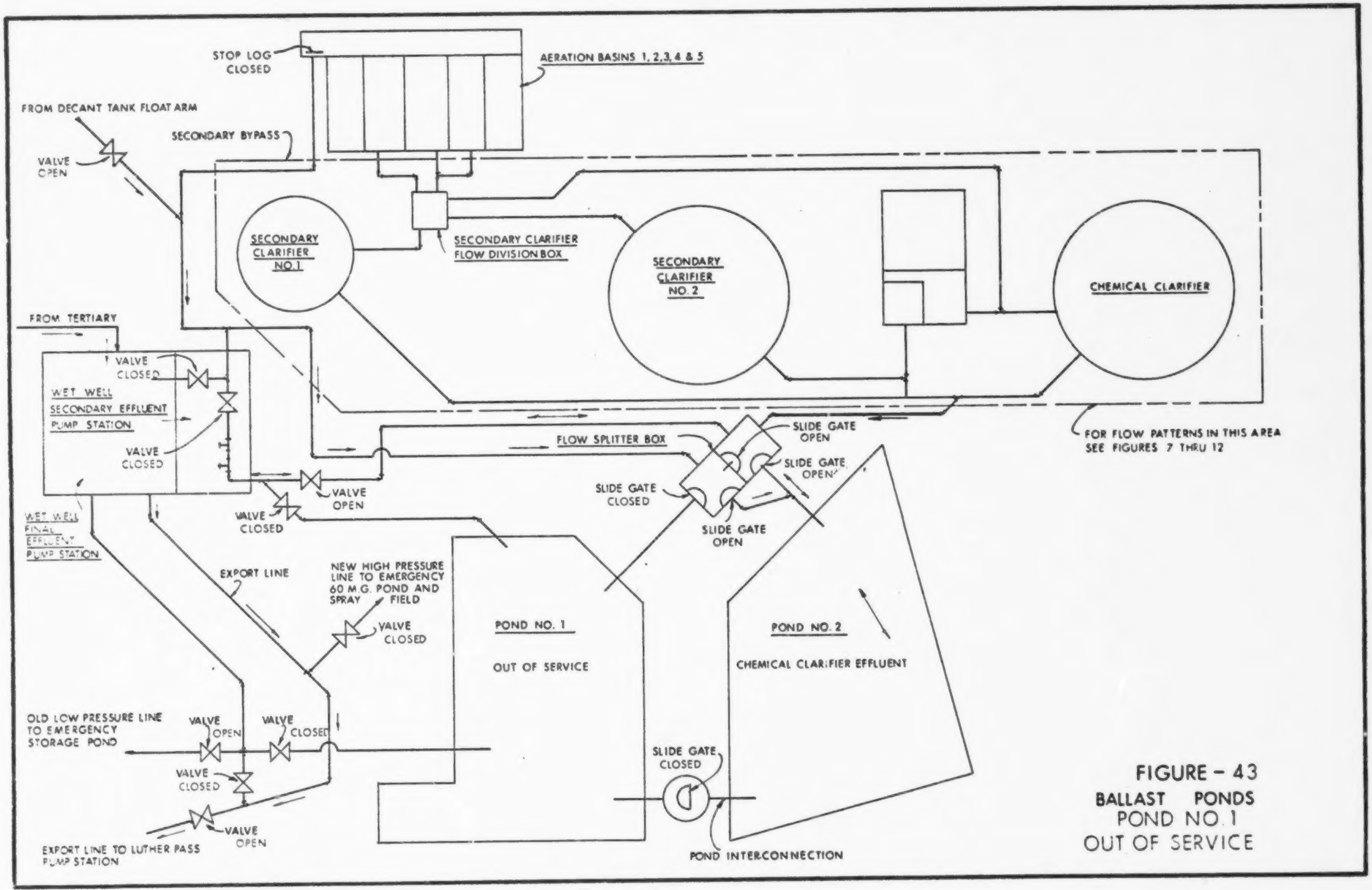

STOP LOG CLOSED
AERATION BASINS 1, 2, 3, 4 & 5
FROM DECANT TANK FLOAT ARM
SECONDARY BYPASS
VALVE OPEN
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER FLOW DIVISION BOX
SECONDARY CLARIFIER NO. 2
CHEMICAL CLARIFIER
FROM TERTIARY
VALVE CLOSED
WET WELL SECONDARY EFFLUENT PUMP STATION
VALVE CLOSED
WET WELL FINAL EFFLUENT PUMP STATION
FLOW SPLITTER BOX
SLIDE GATE OPEN
SLIDE GATE OPEN
SLIDE GATE CLOSED
SLIDE GATE OPEN
FOR FLOW PATTERNS IN THIS AREA SEE FIGURES 7 THRU 12
VALVE OPEN
VALVE CLOSED
EXPORT LINE
NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. POND AND SPRAY FIELD
VALVE CLOSED
POND NO. 1
OUT OF SERVICE
POND NO. 2
CHEMICAL CLARIFIER EFFLUENT
OLD LOW PRESSURE LINE TO EMERGENCY STORAGE POND
VALVE OPEN
VALVE CLOSED
VALVE CLOSED
VALVE OPEN
EXPORT LINE TO LUTHER PASS PUMP STATION
SLIDE GATE CLOSED
POND INTERCONNECTION

FIGURE - 43
BALLAST PONDS
POND NO. 1
OUT OF SERVICE

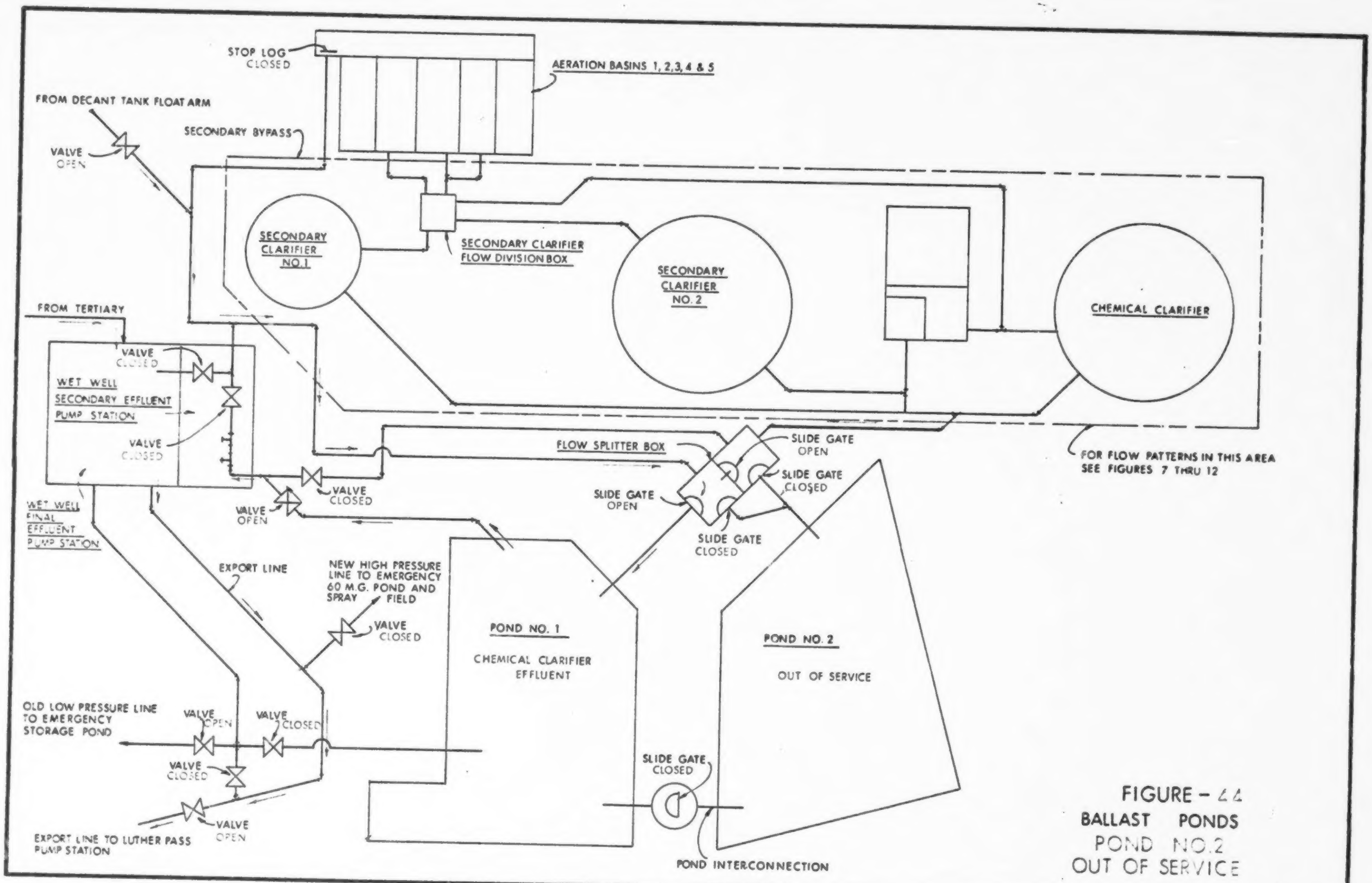

STOP LOG CLOSED
AERATION BASINS 1, 2, 3, 4 & 5
FROM DECANT TANK FLOAT ARM
VALVE OPEN
SECONDARY BYPASS
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER FLOW DIVISION BOX
SECONDARY CLARIFIER NO. 2
CHEMICAL CLARIFIER
FROM TERTIARY
VALVE CLOSED
WET WELL SECONDARY EFFLUENT PUMP STATION
VALVE CLOSED
VALVE CLOSED
VALVE OPEN
WET WELL FINAL EFFLUENT PUMP STATION
FLOW SPLITTER BOX
SLIDE GATE OPEN
SLIDE GATE CLOSED
SLIDE GATE OPEN
SLIDE GATE CLOSED
FOR FLOW PATTERNS IN THIS AREA SEE FIGURES 7 THRU 12
EXPORT LINE
NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. POND AND SPRAY FIELD
VALVE CLOSED
POND NO. 1
CHEMICAL CLARIFIER EFFLUENT
POND NO. 2
OUT OF SERVICE
OLD LOW PRESSURE LINE TO EMERGENCY STORAGE POND
VALVE OPEN
VALVE CLOSED
VALVE CLOSED
VALVE OPEN
EXPORT LINE TO LUTHER PASS PUMP STATION
SLIDE GATE CLOSED
POND INTERCONNECTION

FIGURE - 44
BALLAST PONDS
POND NO. 2
OUT OF SERVICE

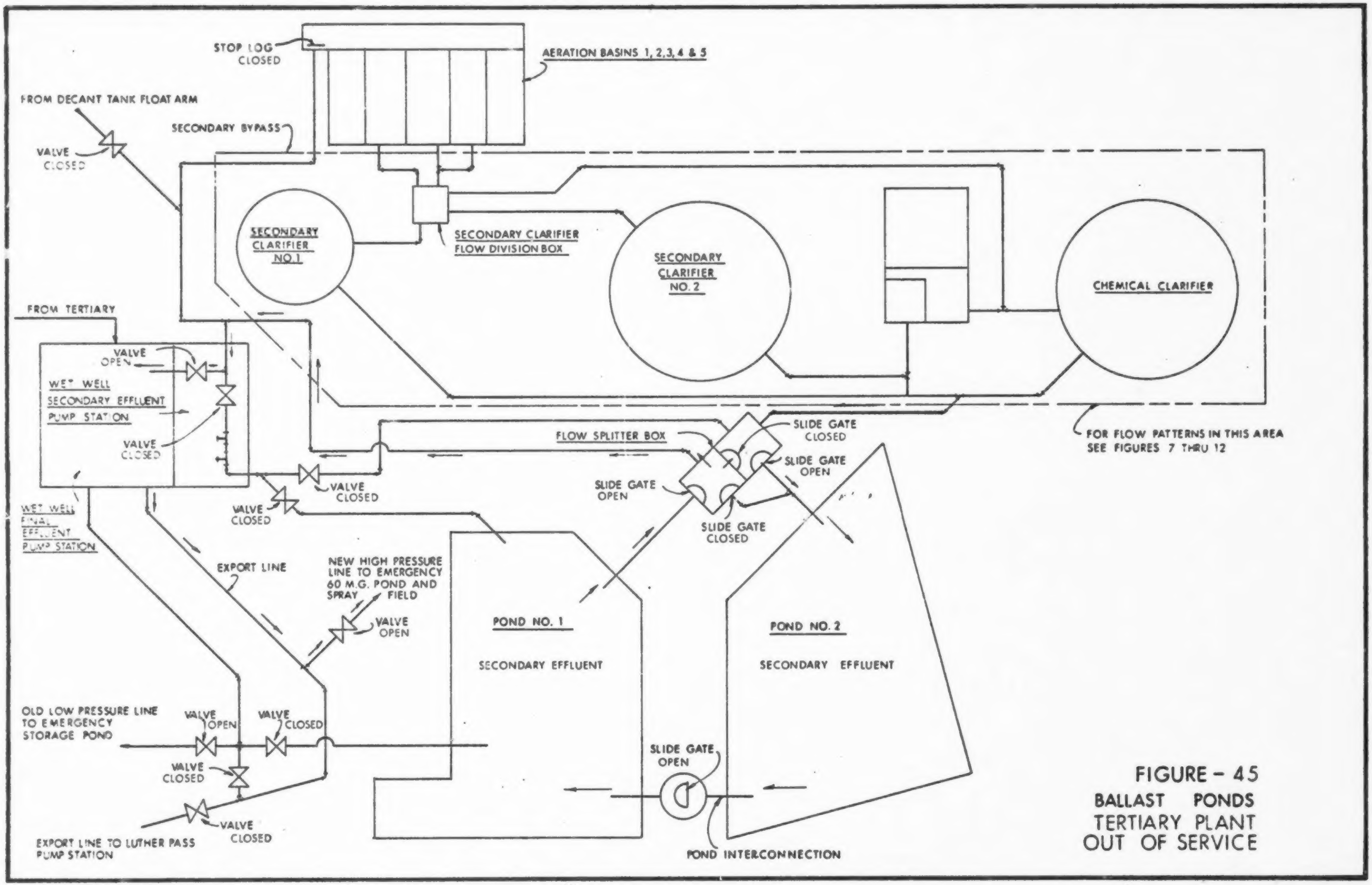

STOP LOG CLOSED
AERATION BASINS 1, 2, 3, 4 & 5
FROM DECANT TANK FLOAT ARM
VALVE CLOSED
SECONDARY BYPASS
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER FLOW DIVISION BOX
SECONDARY CLARIFIER NO. 2
CHEMICAL CLARIFIER
FROM TERTIARY
VALVE OPEN
WET WELL SECONDARY EFFLUENT PUMP STATION
VALVE CLOSED
FLOW SPLITTER BOX
SLIDE GATE CLOSED
SLIDE GATE OPEN
SLIDE GATE OPEN
SLIDE GATE CLOSED
FOR FLOW PATTERNS IN THIS AREA SEE FIGURES 7 THRU 12
VALVE CLOSED
VALVE CLOSED
WET WELL FINAL EFFLUENT PUMP STATION
EXPORT LINE
NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. POND AND SPRAY FIELD
VALVE OPEN
POND NO. 1
SECONDARY EFFLUENT
POND NO. 2
SECONDARY EFFLUENT
OLD LOW PRESSURE LINE TO EMERGENCY STORAGE POND
VALVE OPEN
VALVE CLOSED
VALVE CLOSED
VALVE CLOSED
EXPORT LINE TO LUTHER PASS PUMP STATION
SLIDE GATE OPEN
POND INTERCONNECTION

FIGURE - 45
BALLAST PONDS
TERTIARY PLANT
OUT OF SERVICE

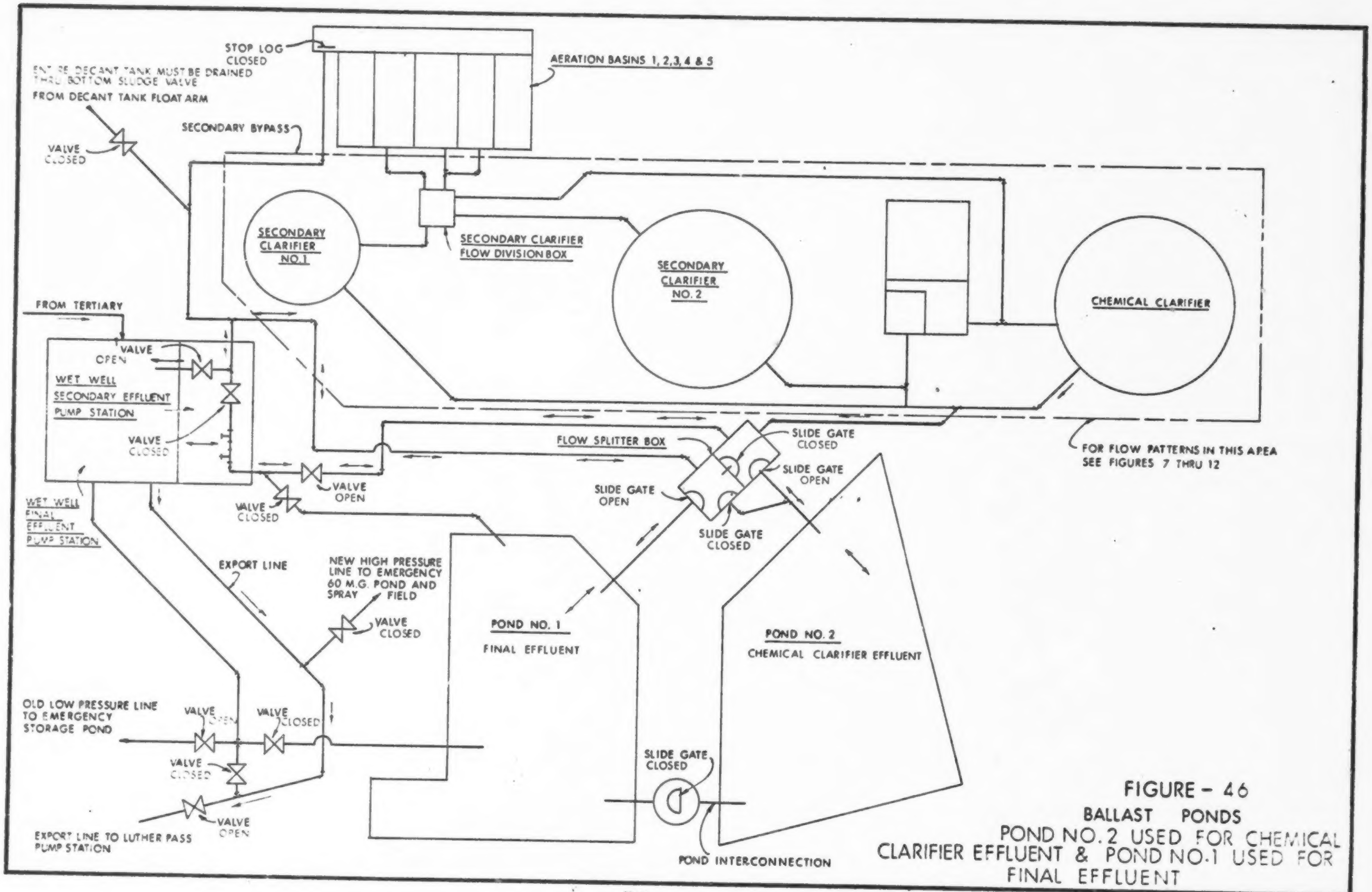

STOP LOG
CLOSED
AERATION BASINS 1, 2, 3, 4 & 5
ENTIRE DECANT TANK MUST BE DRAINED THRU BOTTOM SLUDGE VALVE
FROM DECANT TANK FLOAT ARM
VALVE CLOSED
SECONDARY BYPASS
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER FLOW DIVISION BOX
SECONDARY CLARIFIER NO. 2
CHEMICAL CLARIFIER
FROM TERTIARY
VALVE OPEN
WET WELL SECONDARY EFFLUENT PUMP STATION
VALVE CLOSED
WET WELL FINAL EFFLUENT PUMP STATION
VALVE OPEN
VALVE CLOSED
FLOW SPLITTER BOX
SLIDE GATE CLOSED
SLIDE GATE OPEN
SLIDE GATE OPEN
SLIDE GATE CLOSED
FOR FLOW PATTERNS IN THIS AREA SEE FIGURES 7 THRU 12
EXPORT LINE
NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. POND AND SPRAY FIELD
VALVE CLOSED
POND NO. 1
FINAL EFFLUENT
POND NO. 2
CHEMICAL CLARIFIER EFFLUENT
OLD LOW PRESSURE LINE TO EMERGENCY STORAGE POND
VALVE OPEN
VALVE CLOSED
VALVE CLOSED
VALVE OPEN
EXPORT LINE TO LUTHER PASS PUMP STATION
SLIDE GATE CLOSED
POND INTERCONNECTION

FIGURE - 46
BALLAST PONDS
POND NO. 2 USED FOR CHEMICAL CLARIFIER EFFLUENT & POND NO. 1 USED FOR FINAL EFFLUENT

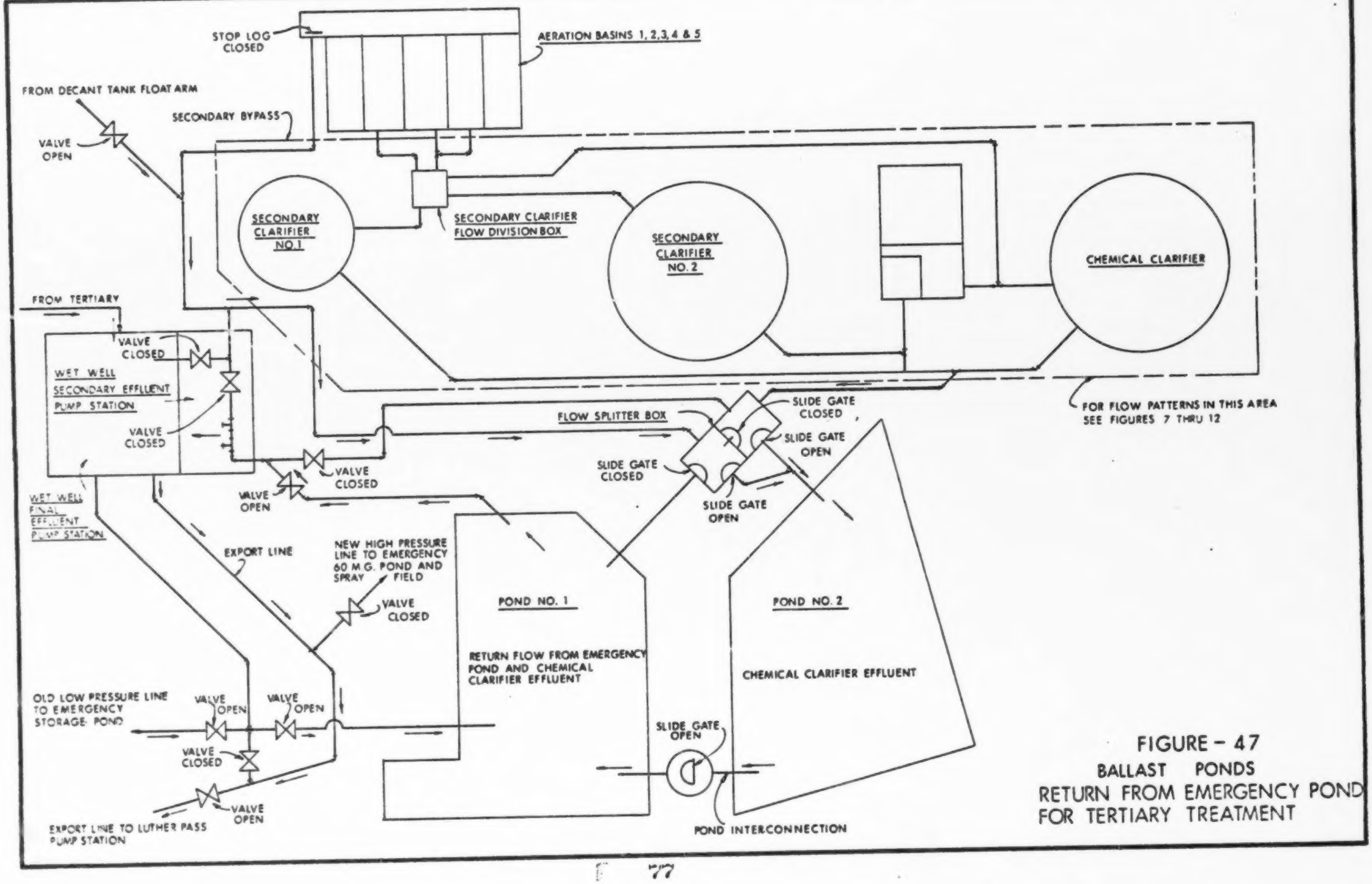

STOP LOG CLOSED
AERATION BASINS 1, 2, 3, 4 & 5
FROM DECANT TANK FLOAT ARM
SECONDARY BYPASS
VALVE OPEN
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER FLOW DIVISION BOX
SECONDARY CLARIFIER NO. 2
CHEMICAL CLARIFIER
FROM TERTIARY
VALVE CLOSED
WET WELL SECONDARY EFFLUENT PUMP STATION
VALVE CLOSED
FLOW SPLITTER BOX
SLIDE GATE CLOSED
SLIDE GATE OPEN
SLIDE GATE CLOSED
SLIDE GATE OPEN
FOR FLOW PATTERNS IN THIS AREA SEE FIGURES 7 THRU 12
VALVE CLOSED
VALVE OPEN
WET WELL FINAL EFFLUENT PUMP STATION
EXPORT LINE
NEW HIGH PRESSURE LINE TO EMERGENCY 60 M.G. POND AND SPRAY FIELD
VALVE CLOSED
POND NO. 1
RETURN FLOW FROM EMERGENCY POND AND CHEMICAL CLARIFIER EFFLUENT
POND NO. 2
CHEMICAL CLARIFIER EFFLUENT
OLD LOW PRESSURE LINE TO EMERGENCY STORAGE POND
VALVE OPEN
VALVE OPEN
VALVE CLOSED
VALVE OPEN
EXPORT LINE TO LUTHER PASS PUMP STATION
SLIDE GATE OPEN
POND INTERCONNECTION

FIGURE - 47
BALLAST PONDS
RETURN FROM EMERGENCY POND
FOR TERTIARY TREATMENT

It should be noted that the old pipeline to the emergency storage pond is a low-pressure (100 psi) line. Therefore, it is VERY IMPORTANT to operate the valves between this old line and the new high-pressure line in the PROPER SEQUENCE to avoid placing high pressures on the low-pressure line.

Separation Beds. There are three pairs of separation beds which operate in parallel. Each pair of beds comprises a unit, and the two beds operate in series during all 3 operational cycles; that is, during filtration, backwash, and filter-to-waste. Normal operation of the separation beds (or filters) is controlled automatically from the MicroFLOC control panel. The order of opening or closing of the various valves is very important and this is discussed in more detail later in this manual. Figure 48 shows the valve positions and flow patterns with the beds in the filter cycle. Figure 49 illustrates the backwash cycle, and Figure 50 shows the valve positions and flow patterns for the filter-to-waste cycle.

The large strainer in the connecting pipeline between Beds No. 1 and 2 is installed for the purpose of straining out filter media flushed out of Bed No. 2 by backwashing, thus preventing it from entering the underdrains in Bed No. 1. Figure 51 shows the internal construction of the strainer. The strainer is built so that coal, sand, and other material strained out of the water is trapped in such a position that it can be flushed out of the bottom of the strainer by opening a valve on the drain line provided. It may also be necessary to stop the backwash flow in order to drain out all of the foreign material from the strainer. The strainer will require frequent flushing during initial startup of the beds, and only very infrequent attention in subsequent routine operation.

Backwash Water Decanting Tank. The backwash water decanting tank may be used in one of two ways: (1) merely as a storage reservoir to equalize the flow and reduce the rate at which water is returned to the treatment process, or, (2) in addition, as a means of separating the sludge from the backwash water by sedimentation, so that the solids and the liquid can be returned to different points in the treatment plant.

Figure 52 pictures normal operation of the decant tank with lime treatment in which the water is separated from the sludge as controlled automatically by the decant cycle timer. The decant cycle takes place immediately after each pair of separation beds is backwashed, in the following sequence:

1. After 0-30 minutes, the decant valve opens.
2. After 0-2 hours, the sludge valve opens.
3. After 0-3 hours, both valves close.

The time for each of these three operations is adjustable. In Figure 52 the clear water decanted (or skimmed) from the water surface in the tank is returned to the ballast ponds, and the bottom sludge is normally returned to the chemical rapid mix basin and thence to the chemical clarifier. Under this plan of operation there are two additional alternate points for discharge of the sludge. They are (1) to the influent of the new primary tank, and (2) to the digesters or sludge drying beds by use of the digester sludge recirculation pumps.

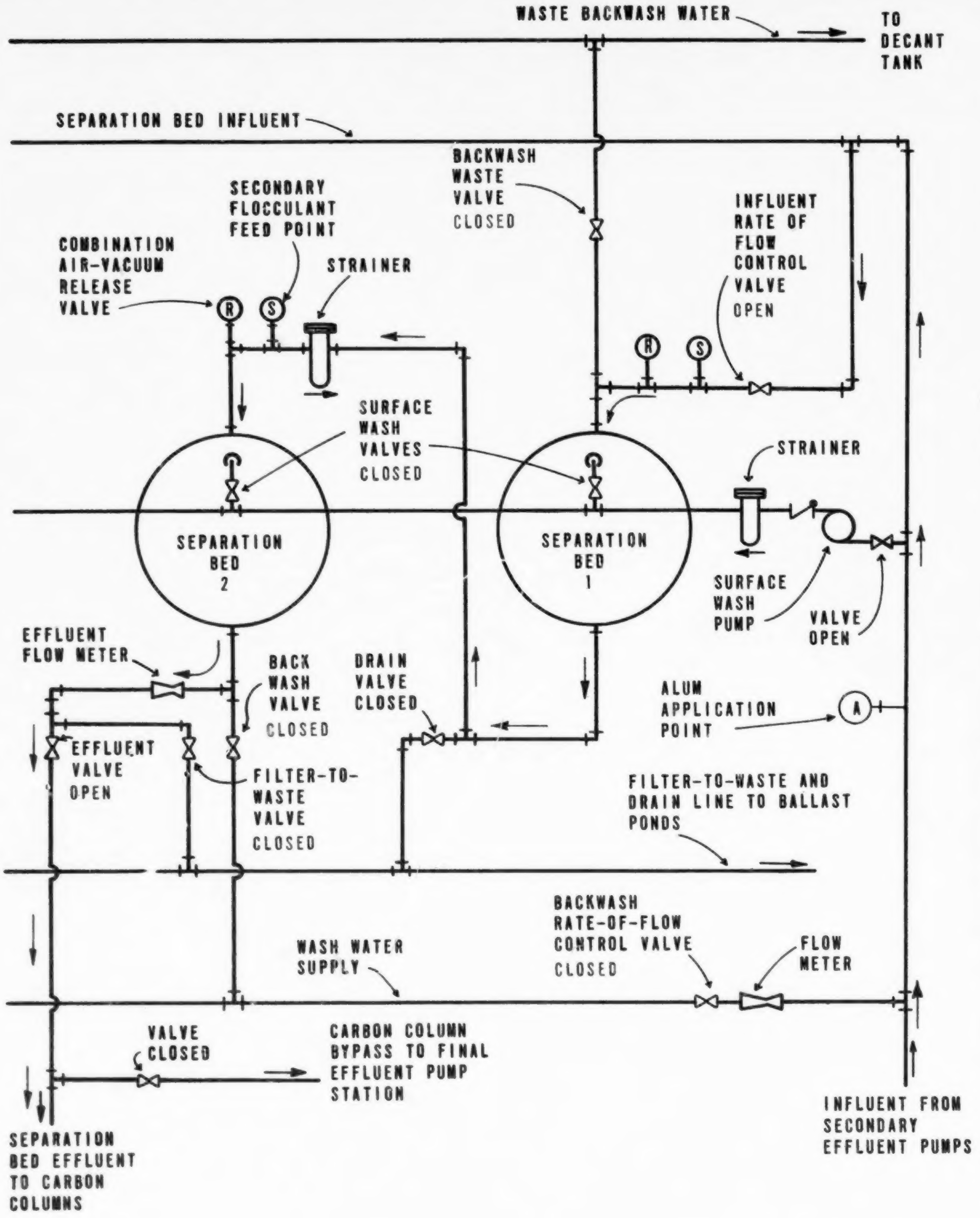

WASTE BACKWASH WATER
TO DECANT TANK
SEPARATION BED INFLUENT
BACKWASH WASTE VALVE CLOSED
SECONDARY FLOCCULANT FEED POINT
COMBINATION AIR-VACUUM RELEASE VALVE
STRAINER
INFLUENT RATE OF FLOW CONTROL VALVE OPEN
R
S
R
S
SURFACE WASH VALVES CLOSED
STRAINER
SEPARATION BED 2
SEPARATION BED 1
SURFACE WASH PUMP
VALVE OPEN
EFFLUENT FLOW METER
BACK WASH VALVE CLOSED
DRAIN VALVE CLOSED
ALUM APPLICATION POINT
A
EFFLUENT VALVE OPEN
FILTER-TO-WASTE VALVE CLOSED
FILTER-TO-WASTE AND DRAIN LINE TO BALLAST PONDS
BACKWASH RATE-OF-FLOW CONTROL VALVE CLOSED
FLOW METER
WASH WATER SUPPLY
VALVE CLOSED
CARBON COLUMN BYPASS TO FINAL EFFLUENT PUMP STATION
INFLUENT FROM SECONDARY EFFLUENT PUMPS
SEPARATION BED EFFLUENT TO CARBON COLUMNS

FIGURE 48
SEPARATION BEDS
FILTER CYCLE

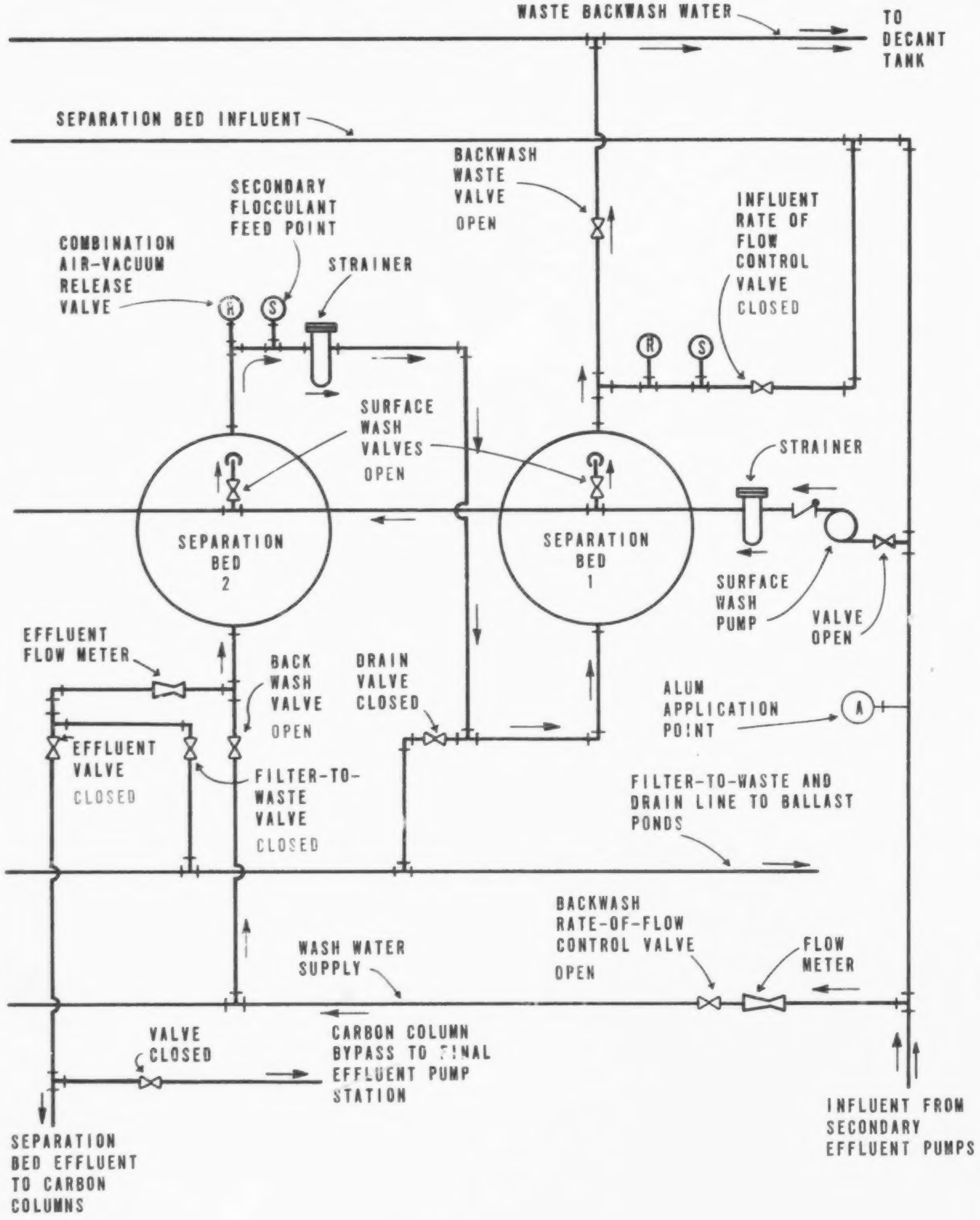

WASTE BACKWASH WATER
TO DECANT TANK
SEPARATION BED INFLUENT
BACKWASH WASTE VALVE OPEN
SECONDARY FLOCCULANT FEED POINT
INFLUENT RATE OF FLOW CONTROL VALVE CLOSED
COMBINATION AIR-VACUUM RELEASE VALVE
STRAINER
R
S
R
S
SURFACE WASH VALVES OPEN
STRAINER
SEPARATION BED 2
SEPARATION BED 1
SURFACE WASH PUMP
VALVE OPEN
EFFLUENT FLOW METER
BACK WASH VALVE OPEN
DRAIN VALVE CLOSED
ALUM APPLICATION POINT
A
EFFLUENT VALVE CLOSED
FILTER-TO-WASTE VALVE CLOSED
FILTER-TO-WASTE AND DRAIN LINE TO BALLAST PONDS
BACKWASH RATE-OF-FLOW CONTROL VALVE OPEN
FLOW METER
WASH WATER SUPPLY
VALVE CLOSED
CARBON COLUMN BYPASS TO FINAL EFFLUENT PUMP STATION
INFLUENT FROM SECONDARY EFFLUENT PUMPS
SEPARATION BED EFFLUENT TO CARBON COLUMNS

FIGURE 49
SEPARATION BEDS
BACKWASH CYCLE

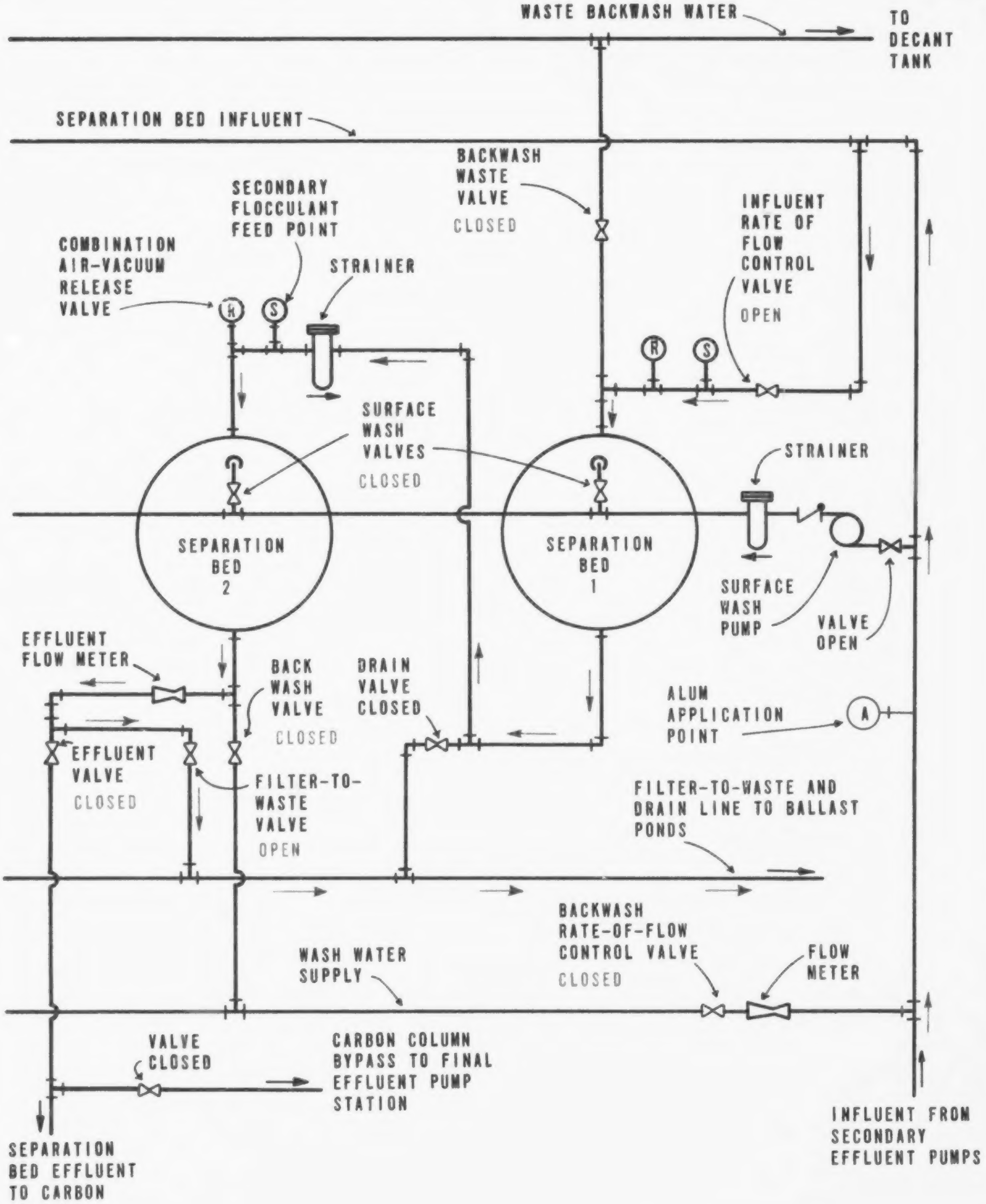


FIGURE 50
SEPARATION BEDS

FILTER-TO-WASTE CYCLE

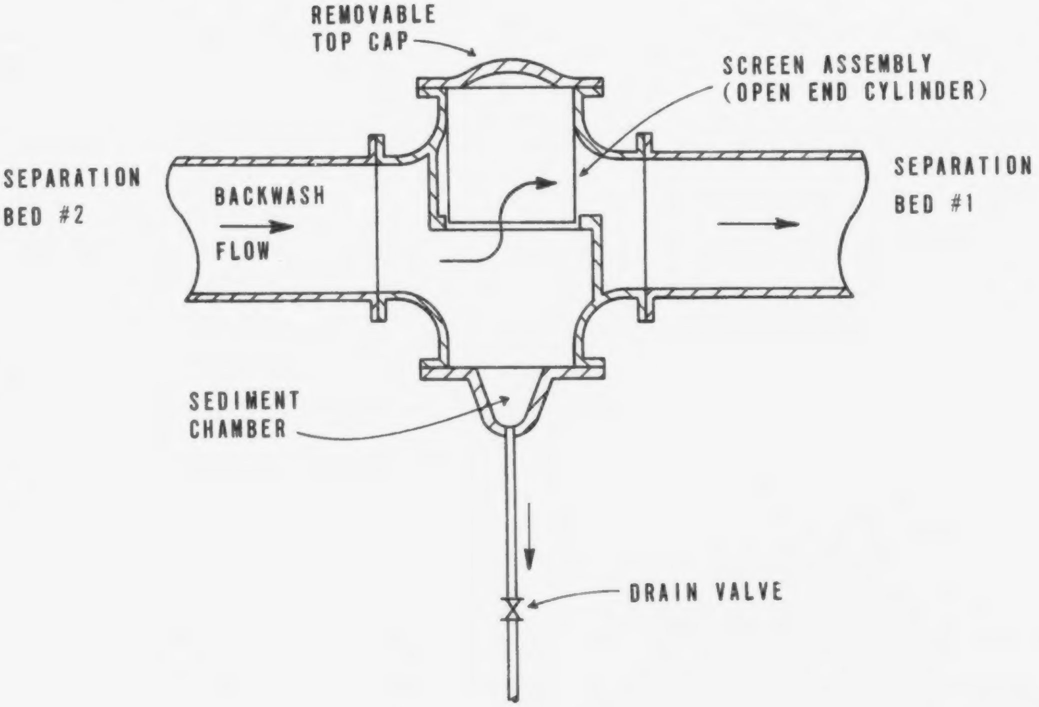


FIGURE 51
STRAINER IN
CONNECTING PIPELINE
BETWEEN FILTER BEDS

Figure 53 shows operation of the decant tank with lime treatment merely as a storage reservoir for equalization of flow only. Under this plan both the sludge and the water are returned together to the treatment process with no attempt at separation. The decant cycle timer is not used, and the decant valve on the pipeline from the floating skimmer arm is always closed. The bottom sludge valve is always open. Figure 53 shows how all of the backwash water and sludge is returned to the rapid mix and thence to the chemical clarifier where the sludge will settle out. As an alternate, all of the backwash water and sludge could be returned to the new primary tank.

Figure 54 shows normal operation when alum, rather than lime, is used as the primary coagulant. The decant cycle timer is used. The clear water is decanted off to the ballast ponds. The bottom sludge passes to the new primary tank along with alum sludge which is pumped from the bottom of the chemical clarifier. Under this plan of operation there are two additional alternate points of discharge for the bottom sludge from the decant tank. They are (1) to the digesters, or (2) to the sludge drying beds.

Figure 55 shows operation of the decant tank with alum treatment merely as a storage reservoir for equalization of flow only. All backwash water and sludge are returned together to the new primary tank with no attempt at separation in the decant tank. The decant cycle timer is not used, the valve on the skimmer arm is always closed, and the bottom sludge valve is open at all times. The alum sludge settles out in the primary tank.

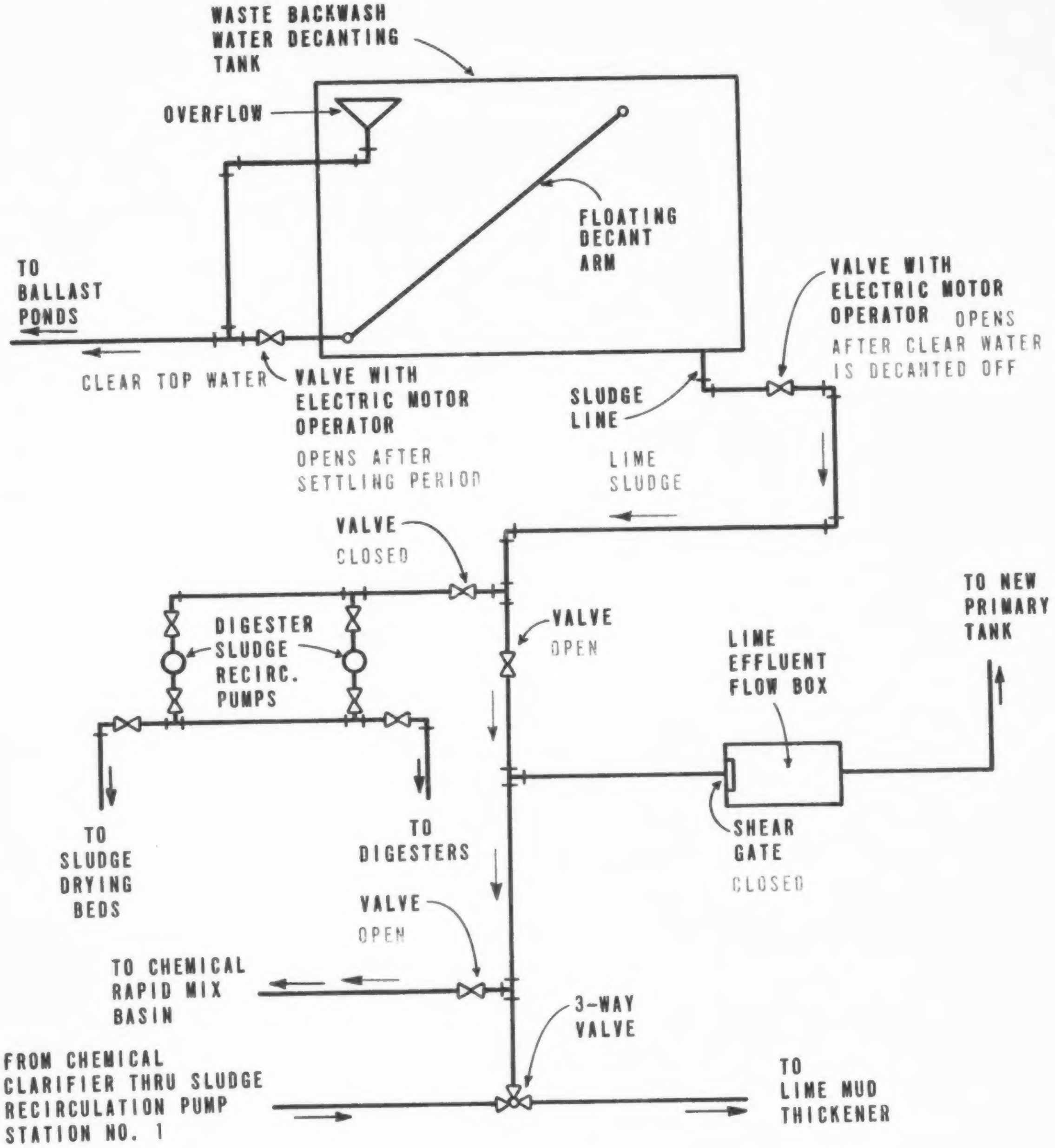

WASTE BACKWASH WATER DECANTING TANK
OVERFLOW
FLOATING DECANT ARM
TO BALLAST PONDS
CLEAR TOP WATER
VALVE WITH ELECTRIC MOTOR OPERATOR
OPENS AFTER SETTLING PERIOD
SLUDGE LINE
VALVE WITH ELECTRIC MOTOR OPERATOR OPENS AFTER CLEAR WATER IS DECANTED OFF
LIME SLUDGE
VALVE
CLOSED
DIGESTER SLUDGE RECIRC. PUMPS
VALVE
OPEN
TO NEW PRIMARY TANK
LIME EFFLUENT FLOW BOX
TO SLUDGE DRYING BEDS
TO DIGESTERS
SHEAR GATE
CLOSED
VALVE
OPEN
TO CHEMICAL RAPID MIX BASIN
3-WAY VALVE
FROM CHEMICAL CLARIFIER THRU SLUDGE RECIRCULATION PUMP STATION NO. 1
TO LIME MUD THICKENER

FIGURE 52
BACKWASH WATER DECANTING TANK
LIME TREATMENT

NORMAL OPERATION WITH DECANT CYCLE TIMER IN USE –
DECANTED WATER TO BALLAST PONDS –
LIME SLUDGE TO CHEMICAL RAPID MIX BASIN

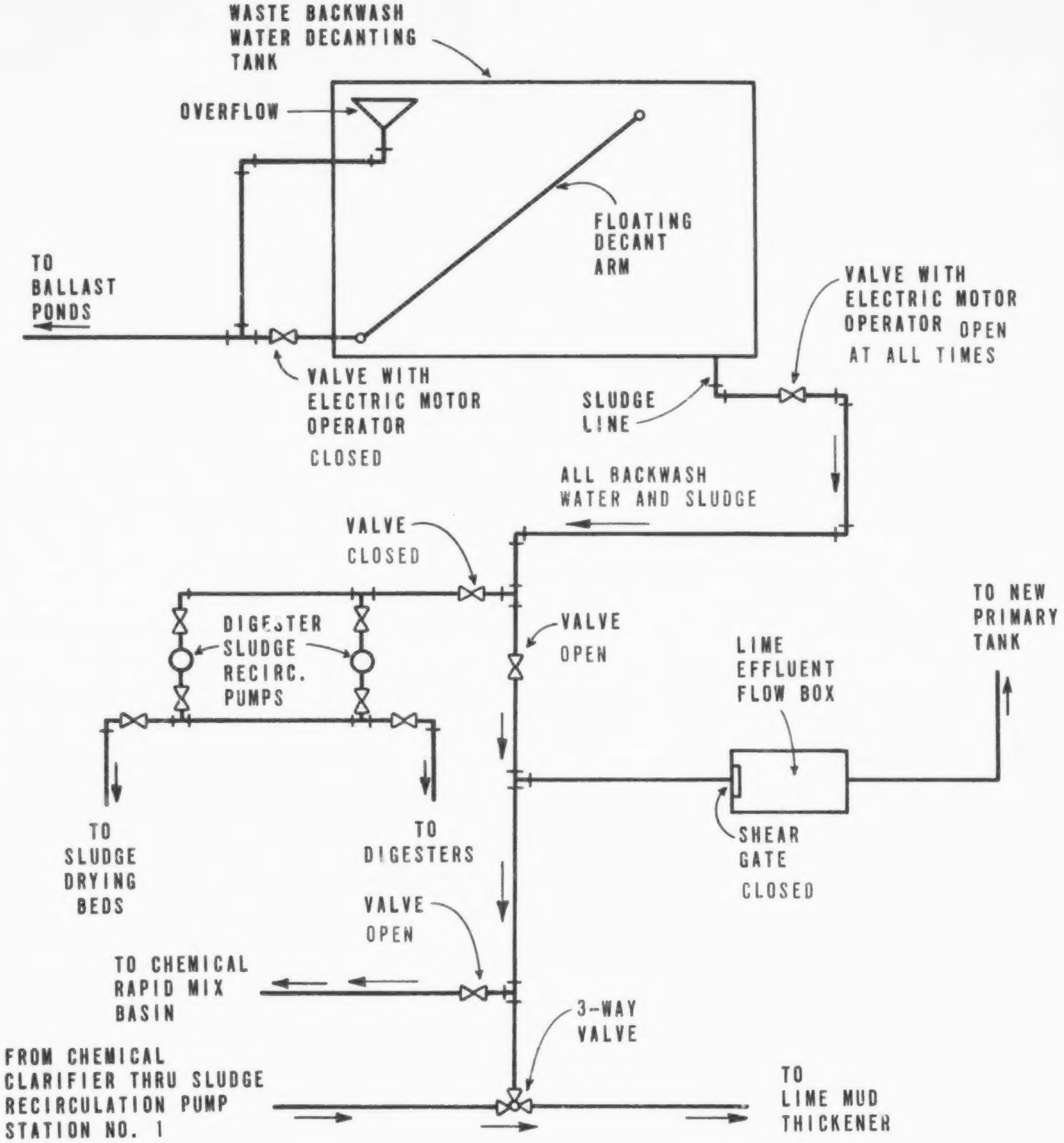

WASTE BACKWASH WATER DECANTING TANK
OVERFLOW
FLOATING DECANT ARM
TO BALLAST PONDS
VALVE WITH ELECTRIC MOTOR OPERATOR OPEN AT ALL TIMES
VALVE WITH ELECTRIC MOTOR OPERATOR
CLOSED
SLUDGE LINE
ALL BACKWASH WATER AND SLUDGE
VALVE
CLOSED
DIGESTER SLUDGE RECIRC. PUMPS
VALVE
OPEN
LIME EFFLUENT FLOW BOX
TO NEW PRIMARY TANK
TO SLUDGE DRYING BEDS
TO DIGESTERS
SHEAR GATE
CLOSED
VALVE
OPEN
TO CHEMICAL RAPID MIX BASIN
3-WAY VALVE
FROM CHEMICAL CLARIFIER THRU SLUDGE RECIRCULATION PUMP STATION NO. 1
TO LIME MUD THICKENER

FIGURE 53
BACKWASH WATER DECANTING TANK
LIME TREATMENT

TANK USED FOR FLOW EQUALIZATION ONLY - ALL BACKWASH WATER FLOWS THROUGH CHEMICAL CLARIFIER DECANT CYCLE TIMER NOT USED.

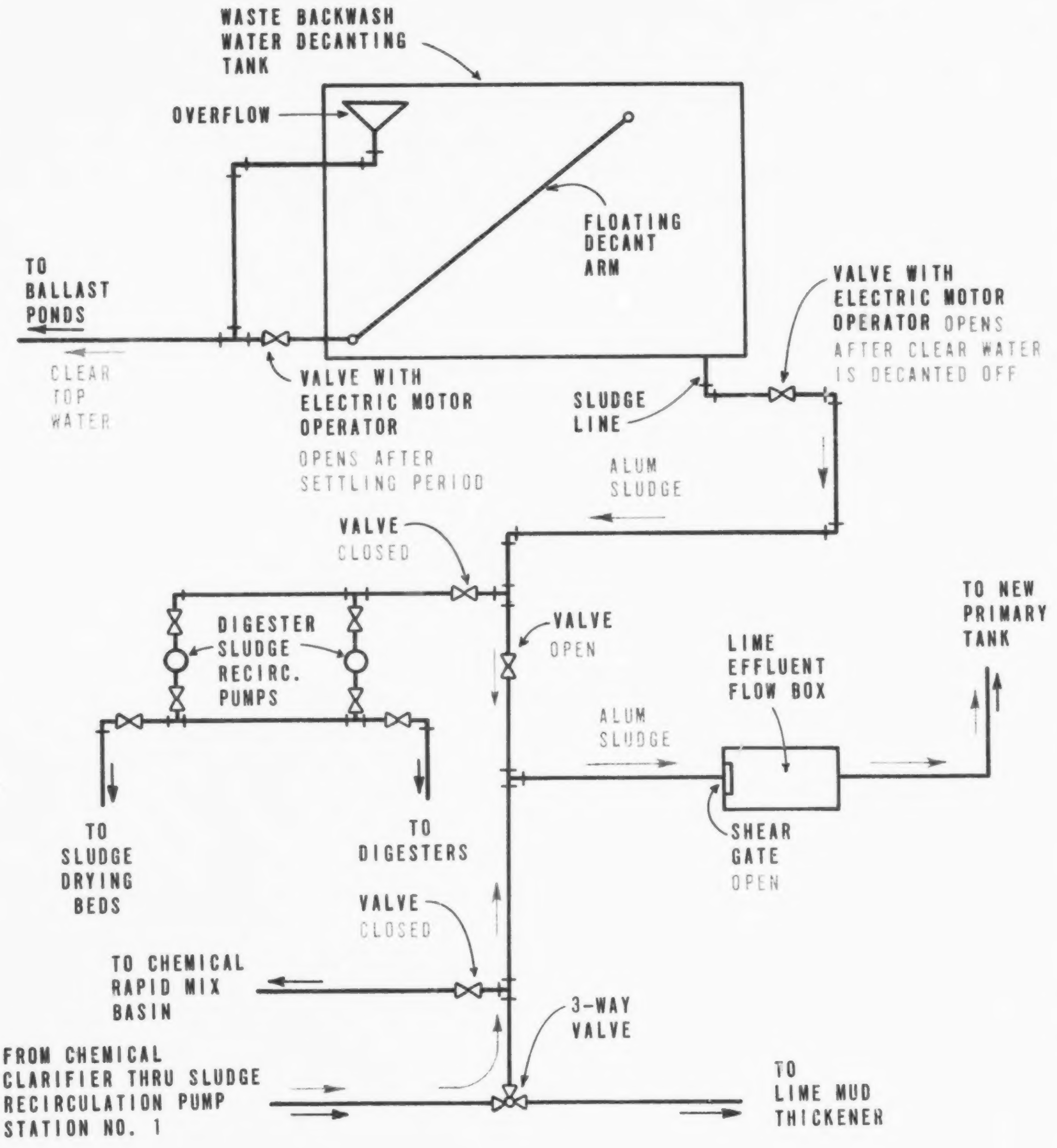

WASTE BACKWASH WATER DECANTING TANK
OVERFLOW
FLOATING DECANT ARM
TO BALLAST PONDS
CLEAR TOP WATER
VALVE WITH ELECTRIC MOTOR OPERATOR
OPENS AFTER SETTLING PERIOD
VALVE WITH ELECTRIC MOTOR OPERATOR OPENS AFTER CLEAR WATER IS DECANTED OFF
SLUDGE LINE
ALUM SLUDGE
VALVE CLOSED
DIGESTER SLUDGE RECIRC. PUMPS
VALVE OPEN
LIME EFFLUENT FLOW BOX
TO NEW PRIMARY TANK
ALUM SLUDGE
SHEAR GATE OPEN
TO SLUDGE DRYING BEDS
TO DIGESTERS
VALVE CLOSED
TO CHEMICAL RAPID MIX BASIN
3-WAY VALVE
FROM CHEMICAL CLARIFIER THRU SLUDGE RECIRCULATION PUMP STATION NO. 1
TO LIME MUD THICKENER

FIGURE 54
BACKWASH WATER DECANTING TANK
ALUM TREATMENT

DECANT CYCLE TIMER IN USE -
ALUM SLUDGE TO PRIMARY TANK -
DECANTED WATER TO BALLAST PONDS

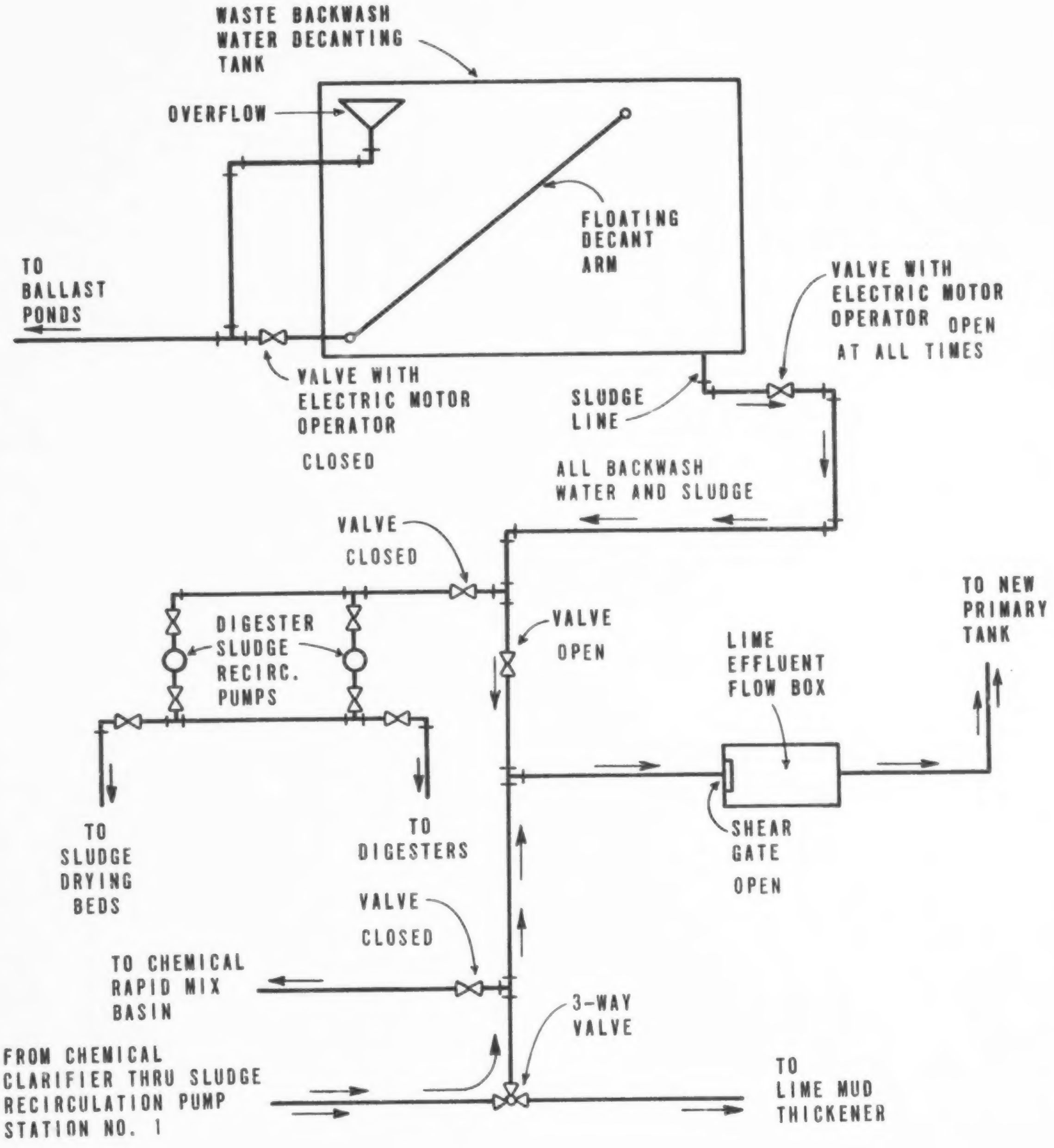

WASTE BACKWASH WATER DECANTING TANK
OVERFLOW
FLOATING DECANT ARM
TO BALLAST PONDS
VALVE WITH ELECTRIC MOTOR OPERATOR
CLOSED
VALVE WITH ELECTRIC MOTOR OPERATOR OPEN AT ALL TIMES
SLUDGE LINE
ALL BACKWASH WATER AND SLUDGE
VALVE
CLOSED
DIGESTER SLUDGE RECIRC. PUMPS
VALVE
OPEN
LIME EFFLUENT FLOW BOX
TO NEW PRIMARY TANK
SHEAR GATE
OPEN
TO SLUDGE DRYING BEDS
TO DIGESTERS
VALVE
CLOSED
TO CHEMICAL RAPID MIX BASIN
3-WAY VALVE
FROM CHEMICAL CLARIFIER THRU SLUDGE RECIRCULATION PUMP STATION NO. 1
TO LIME MUD THICKENER

FIGURE 55
BACKWASH WATER DECANTING TANK
ALUM TREATMENT

TANK USED FOR FLOW EQUALIZATION ONLY - ALL BACKWASH WATER FLOWS THRU NEW PRIMARY TANK - DECANT CYCLE TIMER NOT USED

Carbon Columns. There are eight carbon columns which operate in parallel, each as upflow (countercurrent) columns in normal service. Flow may be reversed for flushing the top screens or compacting the carbon bed. Any or all of the carbon columns may be bypassed. Influent water for the carbon columns comes from the separation beds. Effluent from the carbon columns normally passes on to the final effluent pump station, but may be diverted to the ballast ponds is desired.

Figure 56 shows the valve positions for normal upflow operation of the carbon columns. The valves are manually operated. The flow rate through each carbon column is set by manual operation of a butterfly valve on the carbon column discharge line. There is flow indication at this control valve location.

Figure 57 shows the same flow pattern as for normal operation except that the carbon column effluent is diverted to the ballast ponds. This provides a means of flushing out of carbon fines from the carbon columns when necessary without discharge of carbon particles in the final effluent.

Figure 58 illustrates the method of reversing flow (downflow) through the carbon columns. This flushes the top screens to reduce headloss when headloss (pressure drop) through the carbon columns becomes excessive.

Figure 59 shows how to bypass part or all of the flow around the carbon columns when one or more columns are out of service, or when the influent water quality is not satisfactory for application to the carbon.

Ammonia Stripping Tower and Recarbonation Basins. Figure 60 shows normal operation of the ammonia stripping tower and recarbonation basins. Water flows from the chemical clarifier to the pump sump where it is picked up by the tower pumps which discharge to the top of the stripping tower. Flow from the collection sump beneath the stripping tower passes over a flow measuring weir and is discharged into the primary recarbonation basin. There is a flap valve between the primary recarbonation basin and the tower pump sump. If the tower pumps are discharging more flow than is coming in from the chemical clarifier then the water level in the sump will lower, the flap valve will open, and some tower effluent water will be recirculated by the pumps to the tower. From the primary recarbonation basin, the water flows to the reaction basin where some settling out of calcium carbonate will occur. The settled sludge is collected by a mechanical sludge collector and cross-collector and is discharged periodically to the lime sludge sump in sludge recirculation pump station No. 1. From the reaction basin, the water flows to the secondary recarbonation basin and then to the ballast pond splitter box.

Figure 61 shows how to bypass the stripping tower and keep the recarbonation basins in service. The tower pumps are turned off and the tower bypass slide gate, which is located between the pump sump and primary recarbonation basin, is opened. Flow is by gravity.

Figure 62 illustrates the flow patterns and valve positions when both the ammonia stripping tower and recarbonation basins are bypassed.

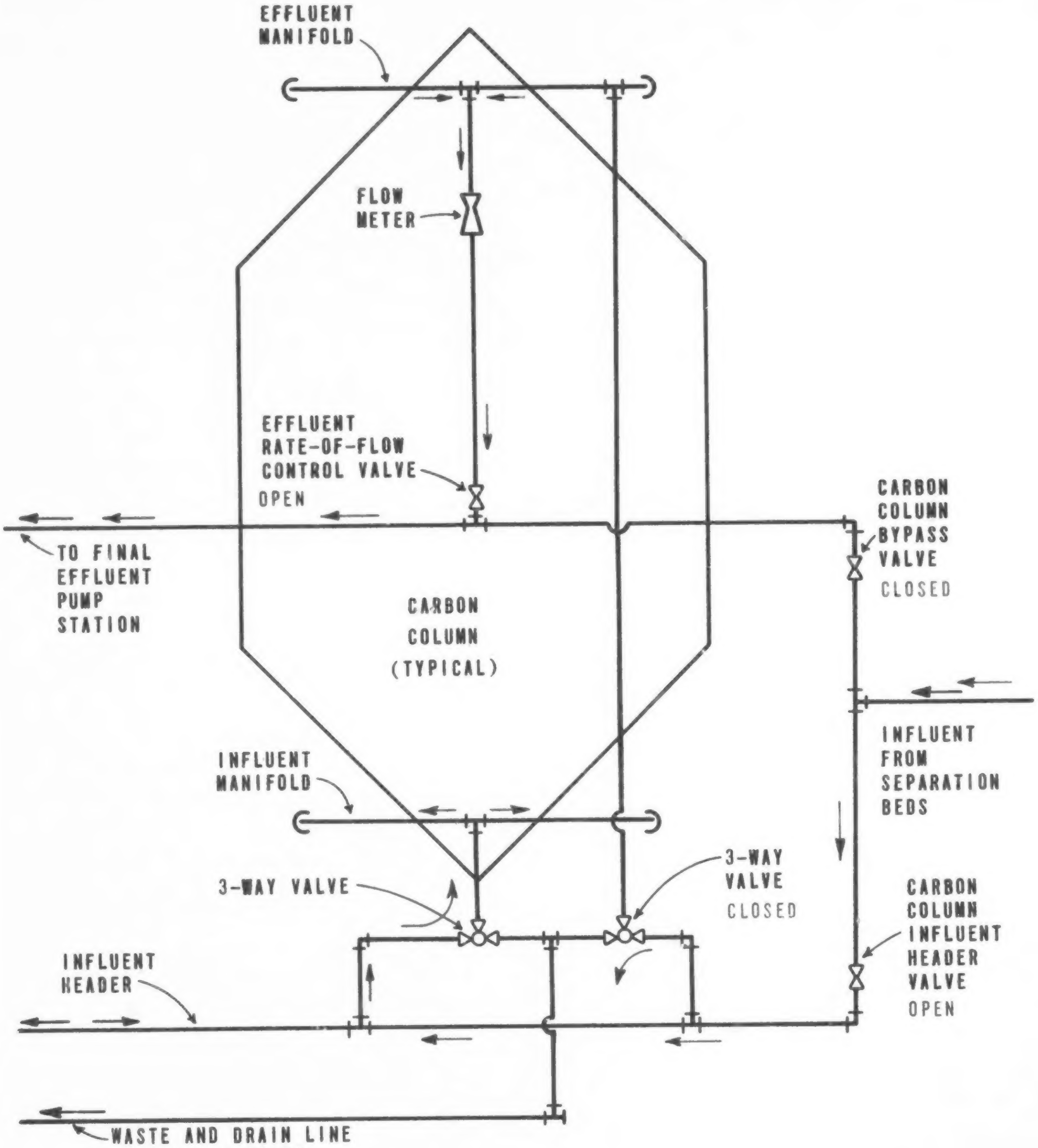

EFFLUENT MANIFOLD
FLOW METER
EFFLUENT RATE-OF-FLOW CONTROL VALVE
OPEN
CARBON COLUMN BYPASS VALVE
CLOSED
TO FINAL EFFLUENT PUMP STATION
CARBON COLUMN (TYPICAL)
INFLUENT FROM SEPARATION BEDS
INFLUENT MANIFOLD
3-WAY VALVE
3-WAY VALVE
CLOSED
CARBON COLUMN INFLUENT HEADER VALVE
OPEN
INFLUENT HEADER
WASTE AND DRAIN LINE TO BALLAST PONDS

FIGURE 56
CARBON COLUMNS
NORMAL UPFLOW OPERATION

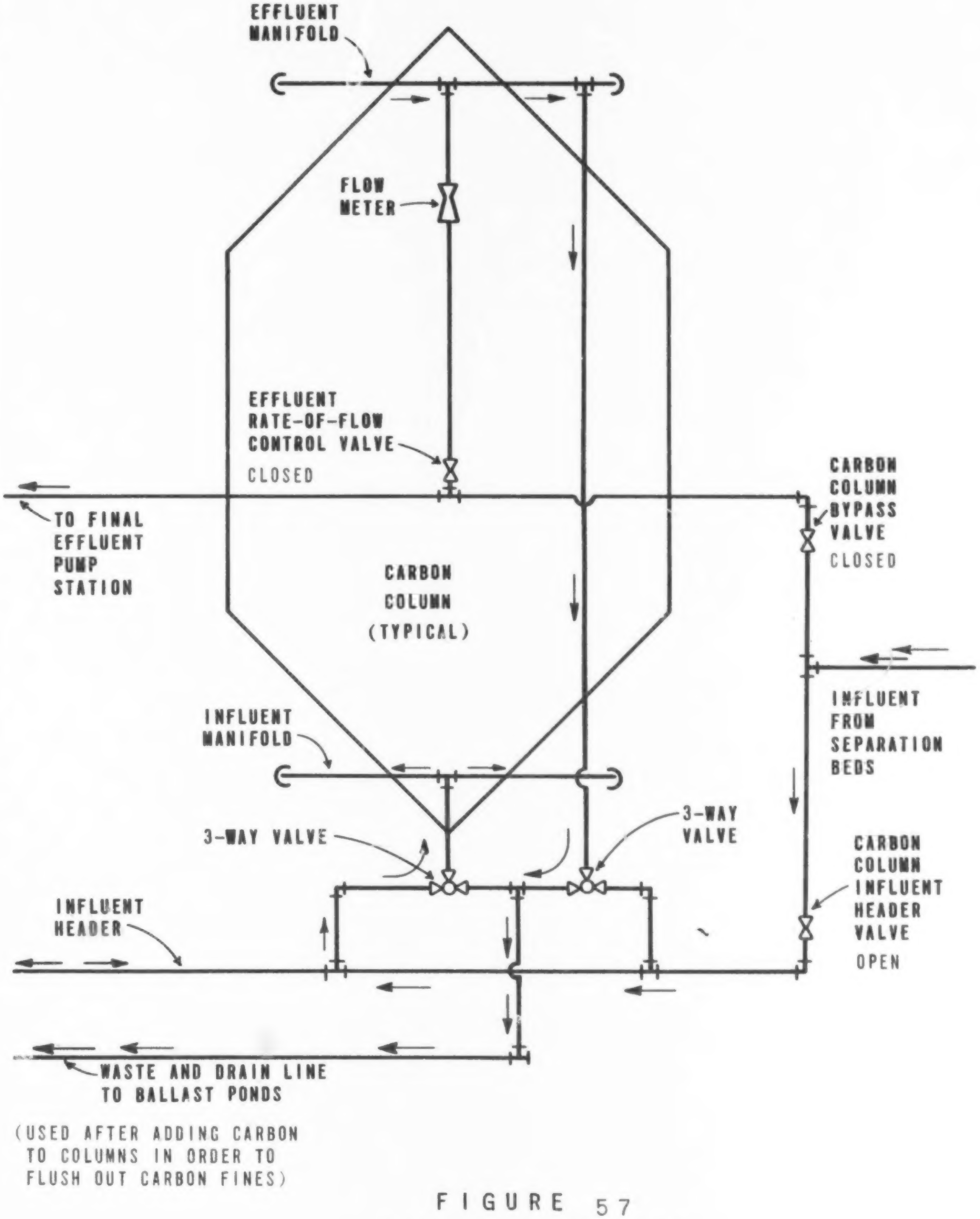

EFFLUENT MANIFOLD
FLOW METER
EFFLUENT RATE-OF-FLOW CONTROL VALVE
CLOSED
TO FINAL EFFLUENT PUMP STATION
CARBON COLUMN (TYPICAL)
CARBON COLUMN BYPASS VALVE
CLOSED
INFLUENT FROM SEPARATION BEDS
INFLUENT MANIFOLD
3-WAY VALVE
3-WAY VALVE
CARBON COLUMN INFLUENT HEADER VALVE
OPEN
INFLUENT HEADER
WASTE AND DRAIN LINE TO BALLAST PONDS
(USED AFTER ADDING CARBON TO COLUMNS IN ORDER TO FLUSH OUT CARBON FINES)

FIGURE 57
CARBON COLUMNS
UPFLOW THROUGH CARBON COLUMN TO WASTE

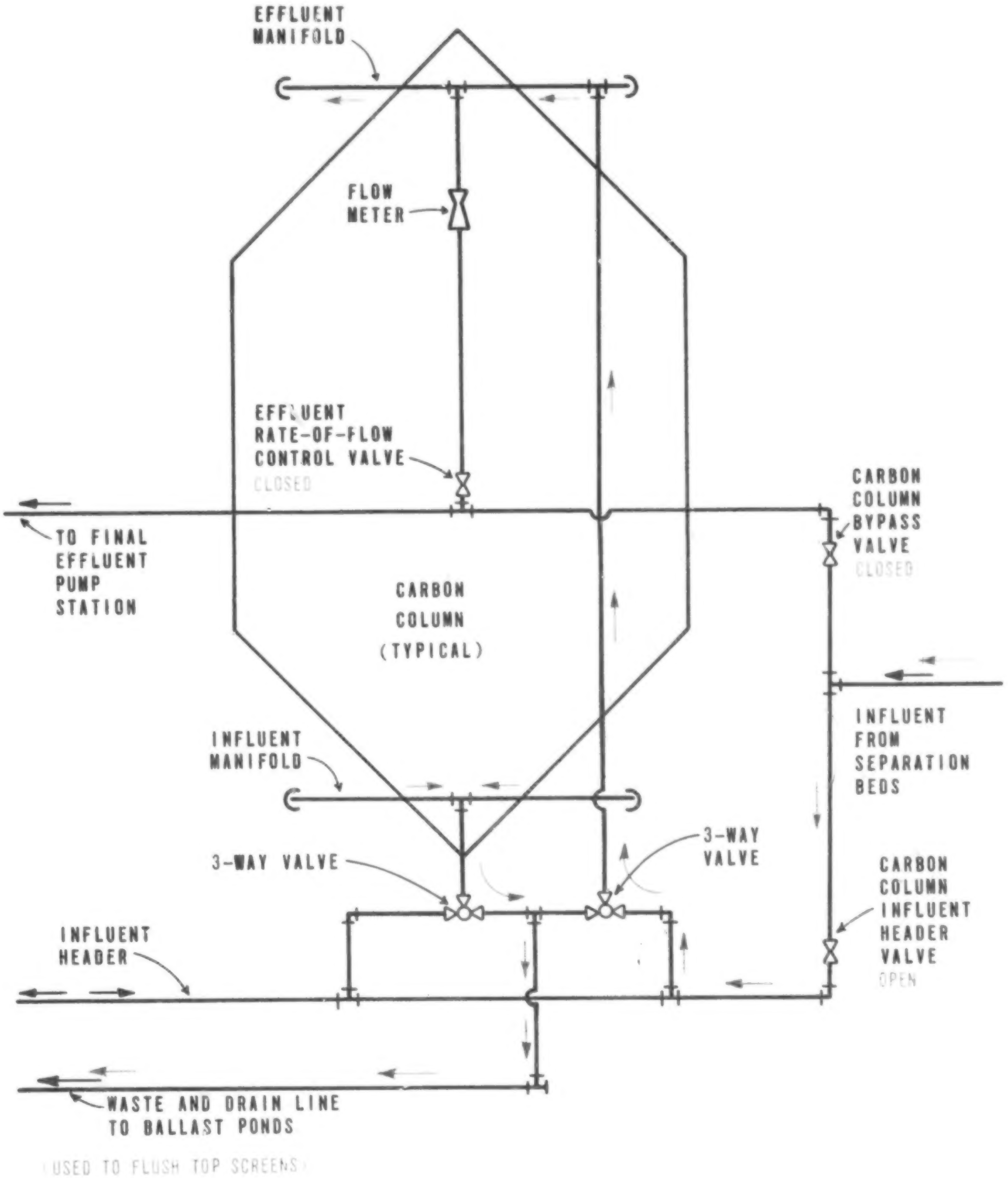

EFFLUENT MANIFOLD
FLOW METER
EFFLUENT RATE-OF-FLOW CONTROL VALVE
CLOSED
TO FINAL EFFLUENT PUMP STATION
CARBON COLUMN (TYPICAL)
CARBON COLUMN BYPASS VALVE
CLOSED
INFLUENT FROM SEPARATION BEDS
INFLUENT MANIFOLD
3-WAY VALVE
3-WAY VALVE
CARBON COLUMN INFLUENT HEADER VALVE
OPEN
INFLUENT HEADER
WASTE AND DRAIN LINE TO BALLAST PONDS
(USED TO FLUSH TOP SCREENS)

FIGURE 53
CARBON COLUMNS
REVERSE FLOW

F. 92

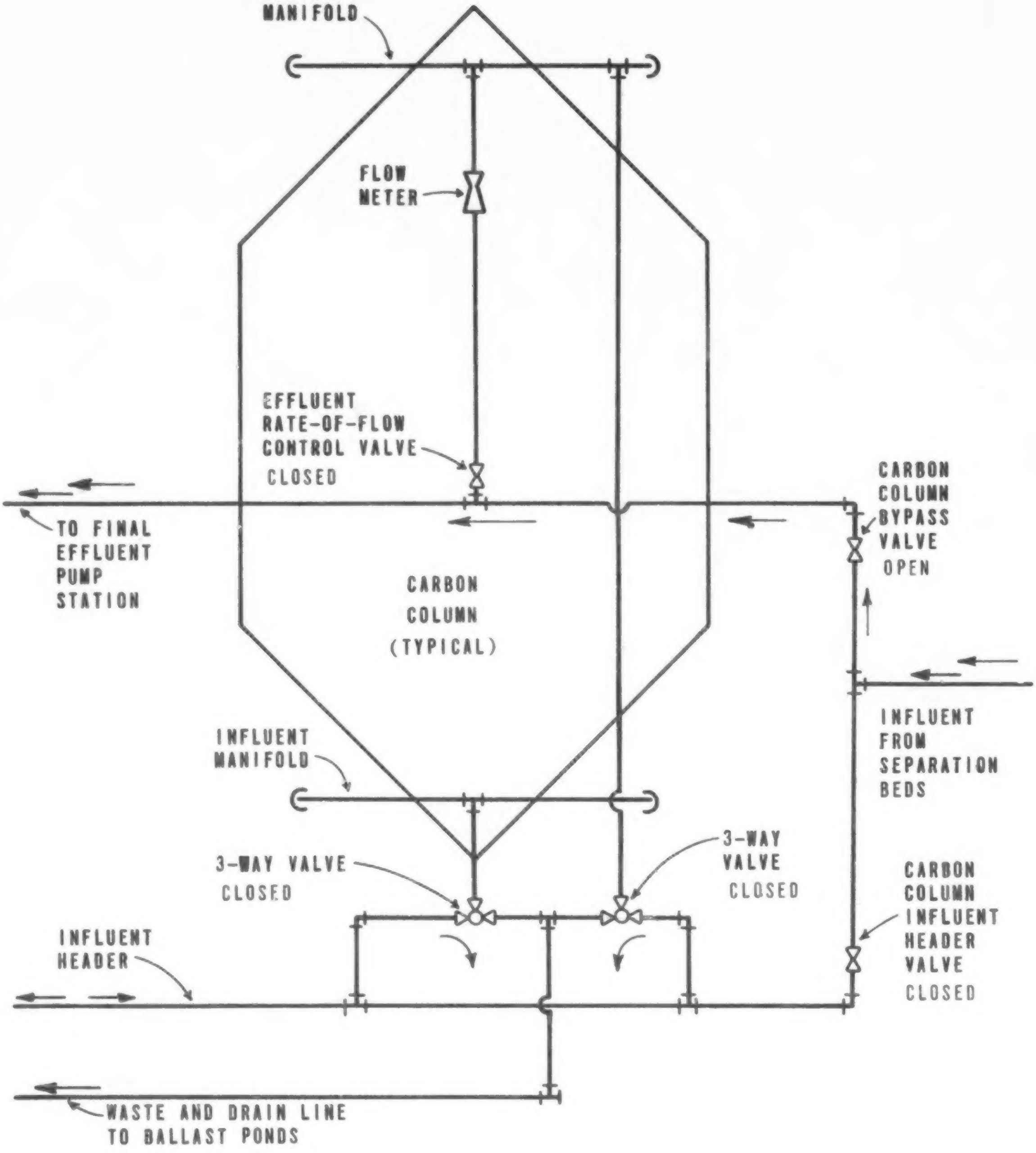

EFFLUENT MANIFOLD
FLOW METER
EFFLUENT RATE-OF-FLOW CONTROL VALVE
CLOSED
CARBON COLUMN BYPASS VALVE
OPEN
TO FINAL EFFLUENT PUMP STATION
CARBON COLUMN (TYPICAL)
INFLUENT FROM SEPARATION BEDS
INFLUENT MANIFOLD
3-WAY VALVE
CLOSED
3-WAY VALVE
CLOSED
CARBON COLUMN INFLUENT HEADER VALVE
CLOSED
INFLUENT HEADER
WASTE AND DRAIN LINE TO BALLAST PONDS

FIGURE 59
CARBON COLUMNS
BY-PASSING CARBON COLUMNS

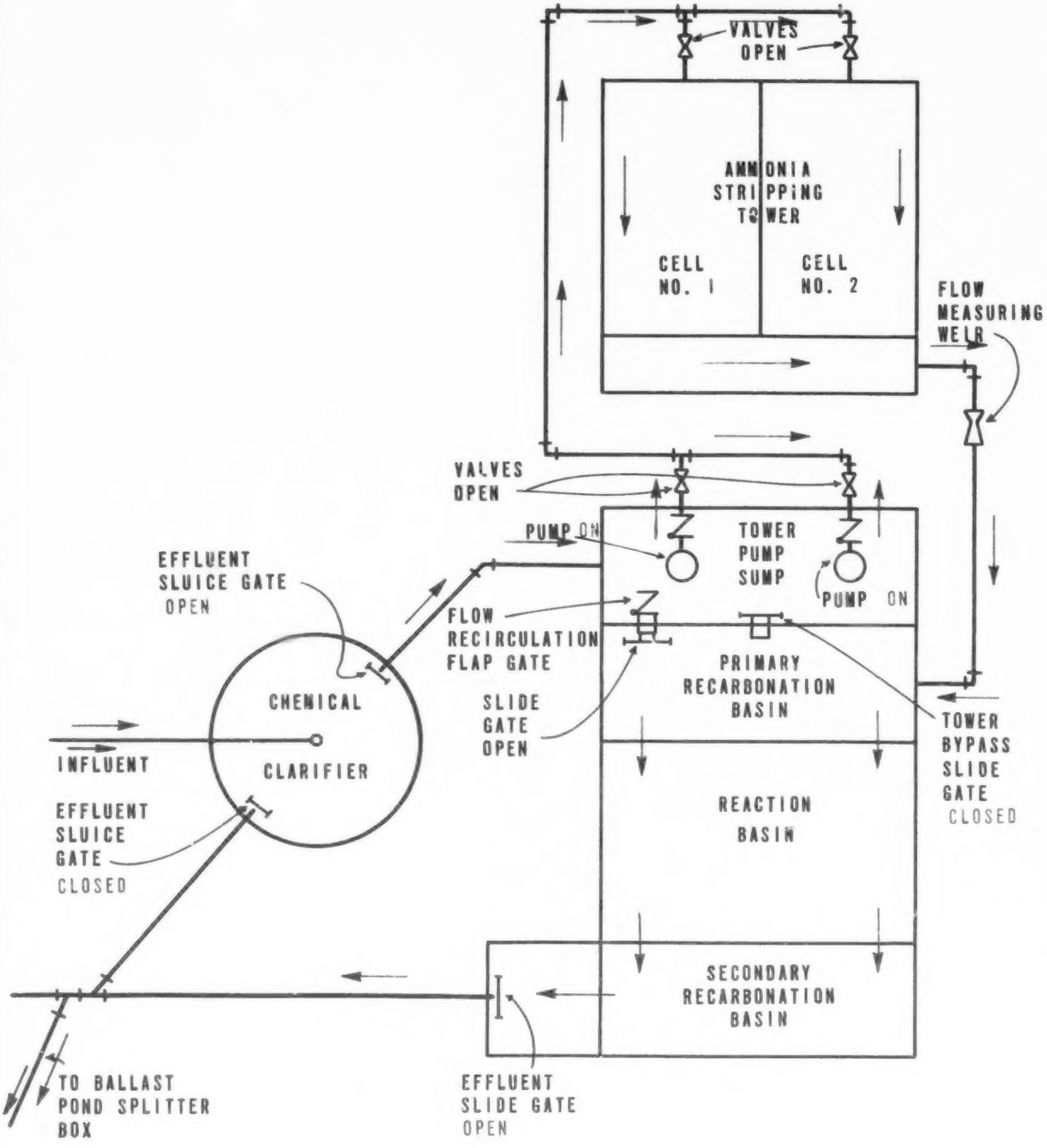

VALVES OPEN
AMMONIA STRIPPING TOWER
CELL NO. 1
CELL NO. 2
FLOW MEASURING WEIR
VALVES OPEN
PUMP ON
TOWER PUMP SUMP
PUMP ON
EFFLUENT SLUICE GATE OPEN
FLOW RECIRCULATION FLAP GATE
SLIDE GATE OPEN
CHEMICAL CLARIFIER
INFLUENT
PRIMARY RECARBONATION BASIN
TOWER BYPASS SLIDE GATE CLOSED
REACTION BASIN
EFFLUENT SLUICE GATE CLOSED
SECONDARY RECARBONATION BASIN
TO BALLAST POND SPLITTER BOX
EFFLUENT SLIDE GATE OPEN

FIGURE 60
AMMONIA STRIPPING TOWER
AND RECARBONATION BASINS
NORMAL OPERATION

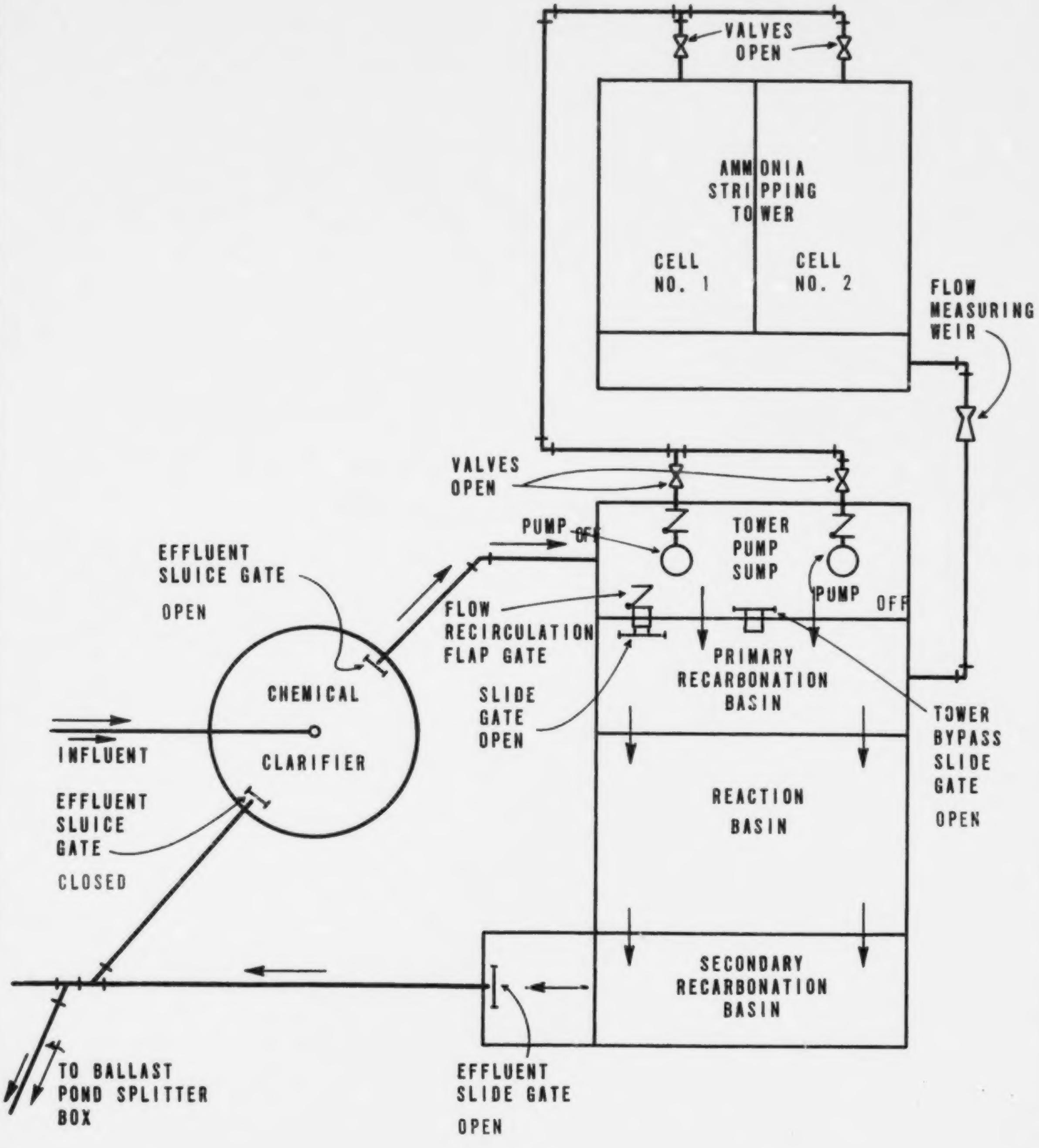


FIGURE 61
AMMONIA STRIPPING TOWER
AND RECARBONATION BASINS
STRIPPING TOWER ONLY BY-PASSED
GRAVITY FLOW THRU RECARBONATION BASINS

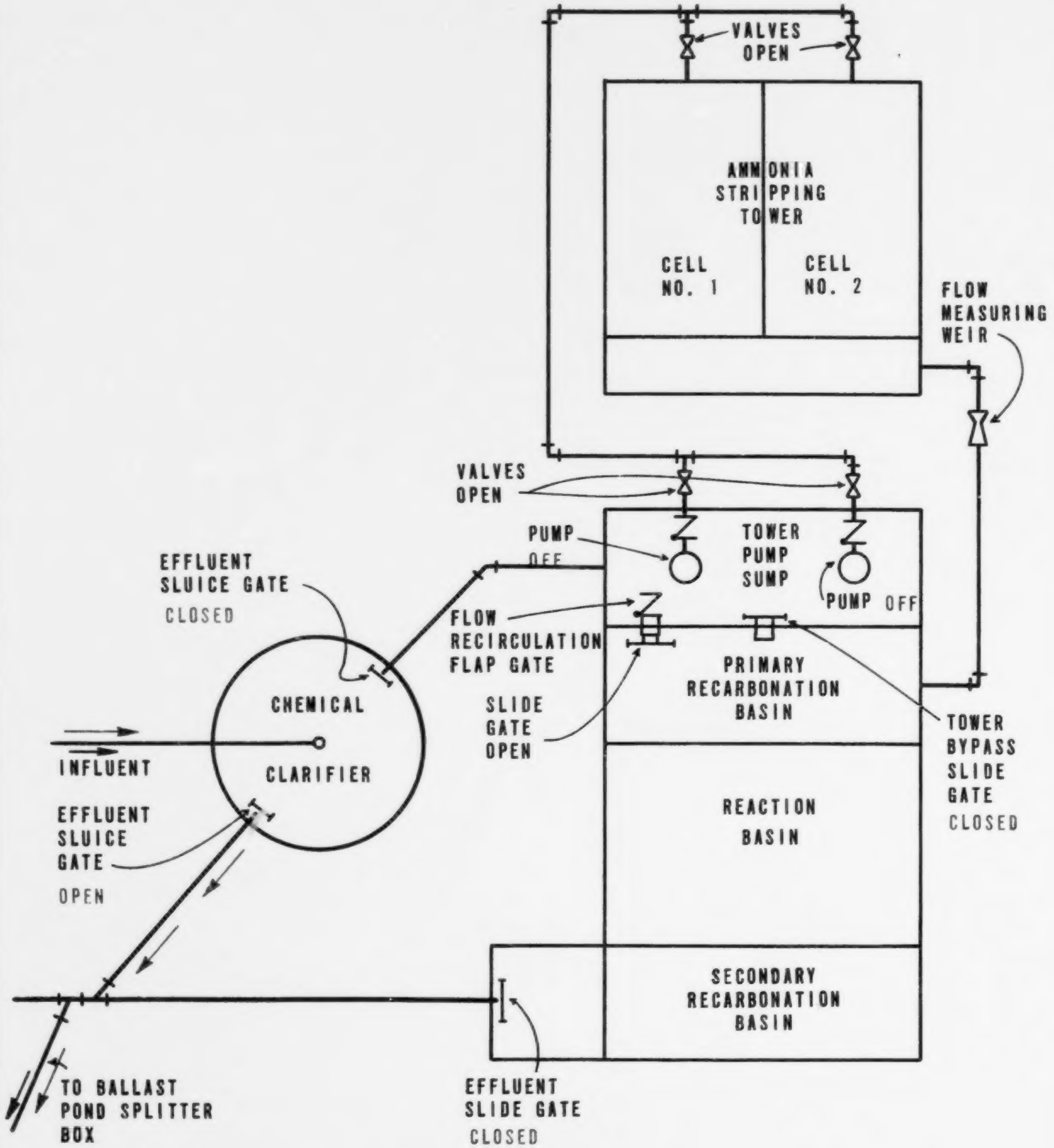

VALVES OPEN
AMMONIA STRIPPING TOWER
CELL NO. 1
CELL NO. 2
FLOW MEASURING WEIR
VALVES OPEN
PUMP OFF
TOWER PUMP SUMP
PUMP OFF
EFFLUENT SLUICE GATE CLOSED
FLOW RECIRCULATION FLAP GATE
SLIDE GATE OPEN
PRIMARY RECARBONATION BASIN
TOWER BYPASS SLIDE GATE CLOSED
CHEMICAL CLARIFIER
INFLUENT
EFFLUENT SLUICE GATE OPEN
REACTION BASIN
SECONDARY RECARBONATION BASIN
TO BALLAST POND SPLITTER BOX
EFFLUENT SLIDE GATE CLOSED

FIGURE 62
AMMONIA STRIPPING TOWER
AND RECARBONATION BASINS
TOWER AND RECARBONATION
BASINS BOTH BY-PASSED

CHEMICAL APPLICATION POINTS

General. This section of the manual deals only with the general features of chemical application such as the points of application which are available, the arrangements for division of chemical feed, and the general methods of chemical feed control.

Details of the methods for mixing chemical solutions, determining and controlling proper dosages, maintenance of equipment, and other information concerning chemical feed are given later in this manual.

Chlorine. As shown on Figure 63, there are three points for application of chlorine solution, (1) the plant influent rising well, (2) the secondary effluent pump sump, and (3) the final effluent pump sump (wet well). Either or both of two chlorinators can feed chlorine to any or all of these three points of application. Chlorine feed to the two pump sumps is regulated manually by a flow division panel located at the intermediate floor level in the final effluent pump station.

The purpose of chlorine feed to the plant influent rising well is for odor control within the treatment plant, particularly for odor control in the primary building.

Chlorine is fed to the tertiary influent (in the secondary effluent pump sump) to extend filter runs and to aid in maintaining clean filter media in the separation beds.

Chlorine is fed to the final effluent for purposes of disinfection of the reclaimed water.

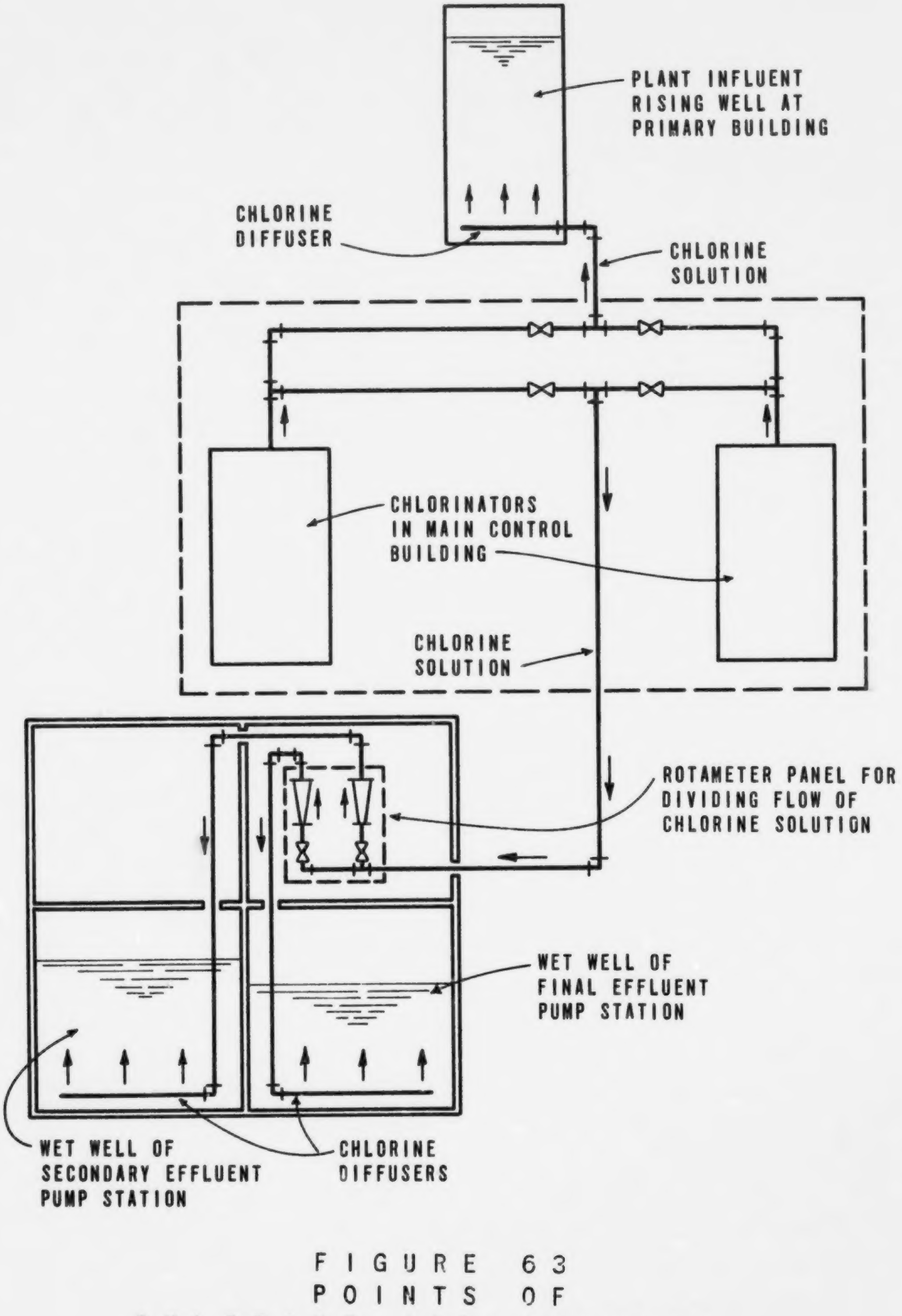

PLANT INFLUENT RISING WELL AT PRIMARY BUILDING
CHLORINE DIFFUSER
CHLORINE SOLUTION
CHLORINATORS IN MAIN CONTROL BUILDING
CHLORINE SOLUTION
ROTAMETER PANEL FOR DIVIDING FLOW OF CHLORINE SOLUTION
WET WELL OF FINAL EFFLUENT PUMP STATION
WET WELL OF SECONDARY EFFLUENT PUMP STATION
CHLORINE DIFFUSERS

FIGURE 63
POINTS OF
CHLORINE APPLICATION

Lime. Two types of lime are used in the plant, (1) fresh quicklime, and (2) recalcined quicklime. The recalcined quicklime also contains some inert ash.

Fresh (or makeup) lime is unloaded in the bulk from delivery trucks by a pneumatic conveying system and discharged into an overhead steel storage bin.

Recalcined lime discharged from the thermal disc cooler at the outlet of the recalcining furnace is conveyed by a separate pneumatic conveying system to an overhead steel storage bin.

The pneumatic conveying systems take suction from a single point, but either of the conveying systems may discharge to either lime storage bin.

There are two paste-type lime feeders and slakers, one for each storage bin. The lime feeder for the fresh (or makeup) lime is paced by a pH signal from the flocculator basin. Ordinarily the controller would be set to maintain a pH of 11 in the flocculation basin. The lime feeder for recalcined lime is paced by a pH signal from the primary clarifier effluent. Ordinarily the controller would be set to maintain a pH of 9.3 or less in the primary clarifier effluent. An increase in lime feed increases the pH of the water and a decrease in the lime feed decreases the pH of the water being treated with lime.

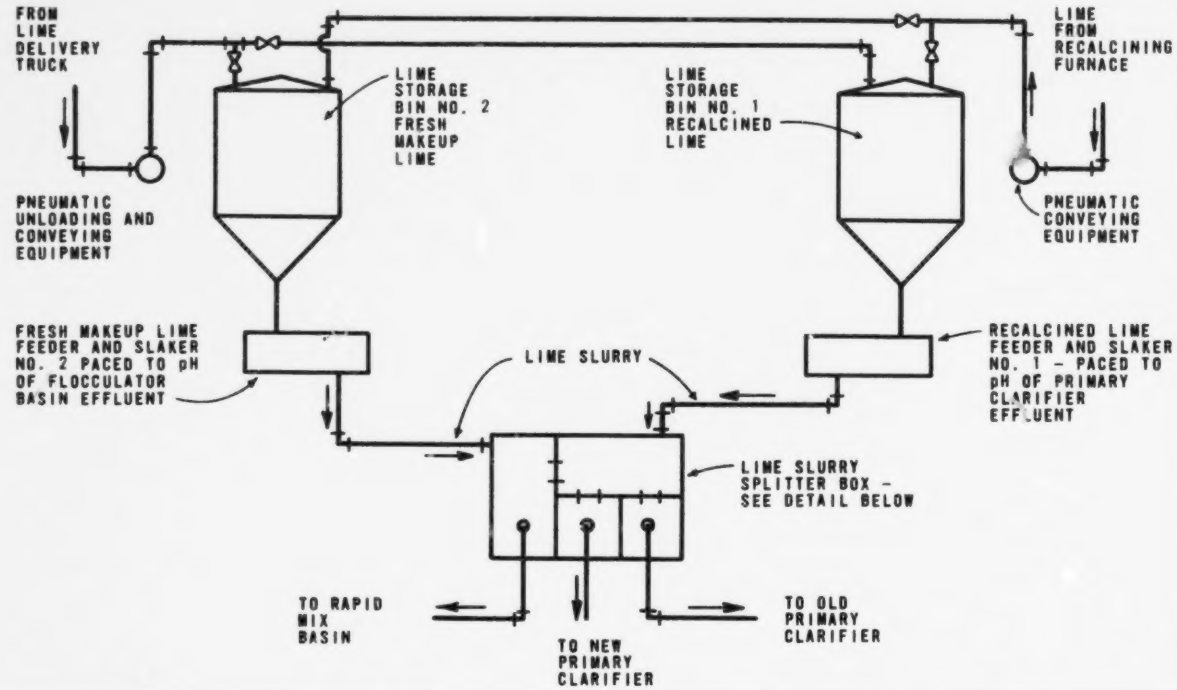
The lime slurry from the two feeders flows to a splitter box as shown by Figure 64. Ordinarily all of the fresh lime slurry would be applied in the rapid mix basin ahead of the flocculator and chemical clarifier. The recalcined lime slurry feed ordinarily would be divided between the rapid mix and the primary clarifiers. The proportion of recalcined lime fed to the rapid mix versus the primary clarifiers is manually controlled by an adjustable length weir.

Increasing the length of the weir increases the proportion of recalcined lime fed to the rapid mix and decreases the proportion fed to the primary clarifier. A high level alarm from the recalcined lime bin or a low level alarm from the fresh lime bin requires an increase in the length of the adjustable weir.

Decreasing the length of the adjustable weir decreases the proportion of recalcined lime fed to the rapid mix and increases the proportion fed to the primary clarifiers. A low level alarm from the recalcined lime bin requires a decrease in the length of the adjustable weir.

The split of recalcined lime slurry to each of the two primary clarifiers is controlled by two fixed V-notch weirs which are sized to proportion the lime feed in accordance with the quantity of water treated by each of the primary clarifiers. This is a constant ratio.

POINTS OF LIME APPLICATION


FROM LIME DELIVERY TRUCK
LIME STORAGE BIN NO. 2 FRESH MAKEUP LIME
LIME STORAGE BIN NO. 1 RECALCINED LIME
LIME FROM RECALCINING FURNACE
PNEUMATIC UNLOADING AND CONVEYING EQUIPMENT
PNEUMATIC CONVEYING EQUIPMENT
FRESH MAKEUP LIME FEEDER AND SLAKER NO. 2 PACED TO pH OF FLOCCULATOR BASIN EFFLUENT
LIME SLURRY
RECALCINED LIME FEEDER AND SLAKER NO. 1 - PACED TO pH OF PRIMARY CLARIFIER EFFLUENT
LIME SLURRY SPLITTER BOX - SEE DETAIL BELOW
TO RAPID MIX BASIN
TO NEW PRIMARY CLARIFIER
TO OLD PRIMARY CLARIFIER

ENLARGED DETAIL OF LIME SLURRY SPLITTER BOX

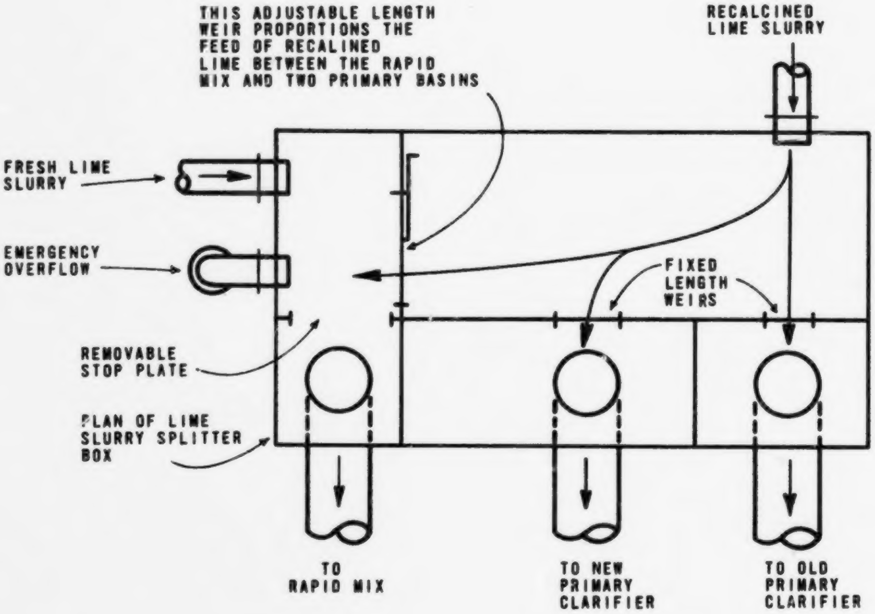


FIGURE 64 - LIME APPLICATION

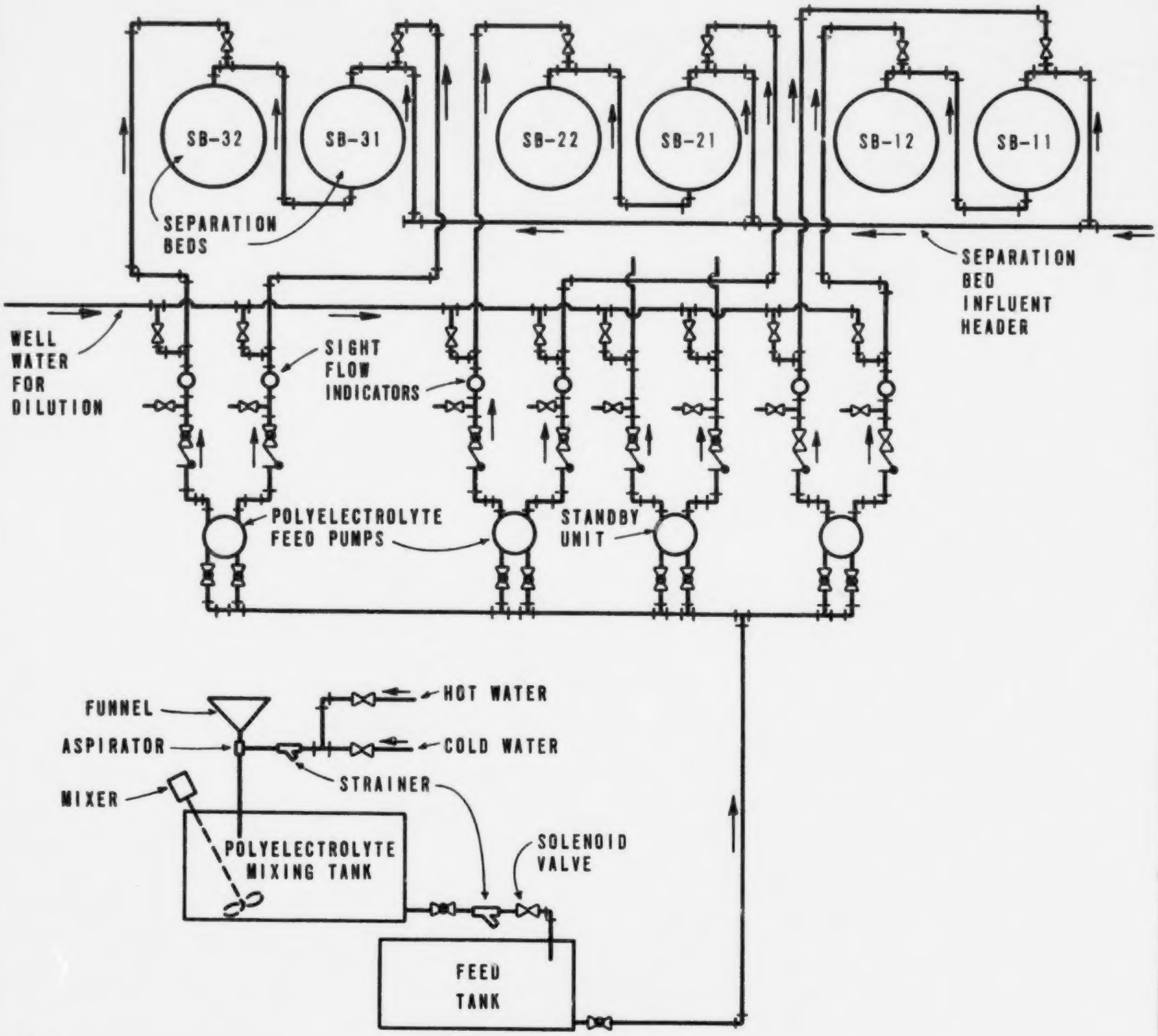
Polyelectrolyte. Polyelectrolytes are used at several points in the plant for different purposes. They are used as aids in filtration, coagulation, flocculation, and sludge conditioning.

1. In the tertiary plant polyelectrolytes are used continuously as filter aids in the separation beds. The material used for this purpose is a nonionic such as Purifloc N-11, Magnifloc 990, or similar ones. There are four solution feed pumps for this service. Each pump has two feed heads. Three pumps are always in use and one pump is a standby unit. There are three pairs of separation beds: (1) SB-11 and SB-12, (2) SB-21 and SB-22, and (3) SB-31 and SB-32. Each separation bed is fed by a separate feed head. This gives separate individual control of polyelectrolyte feed to each separation bed by adjusting the length of stroke for the feed head which serves a particular separation bed. All 3 feeders are paced to flow through the beds by an on-off cycle of feeder operation. Figure 65 illustrates the arrangement for feeding polyelectrolyte to the separation beds. The methods of making the proper strength of polyelectrolyte (secondary floc) solution, and of determining the proper dosage are discussed later in this manual.

2. By use of the standby feeder, shown on Figure 65, it is also possible to feed polyelectrolyte as an aid to coagulation and flocculation to the: (1) plant influent rising well ahead of the primary clarifiers, (2) the rapid mix basin ahead of the chemical clarifier, and (3) the primary recarbonation basin ahead of the reaction basin. At this time, it appears that polyelectrolyte feed to any of these points would not be a part of normal operation.

3. Separate facilities are provided in the old primary building for mixing and feeding polyelectrolyte to the float thickener consisting of a single 350-gallon mixing and feed tank, a mechanical mixer, and a single solution feed pump. The best polyelectrolyte for thickening of the waste activated sludge can only be determined by trial in actual plant operation, but may be Rohm and Haas C-7 or another cationic material. The polyelectrolyte will be applied to the waste activated sludge from the flow division box as it enters the floatation thickener as shown by Figure 36. Depending on the speed with which the particular polyelectrolyte used dissolves, it may be necessary to stop the wasting of activated sludge during the mixing of a new batch of solution.

The float thickener polyelectrolyte feeder is manually controlled by variable speed or by stroke adjustment. The dosage is set to correspond to the flow of waste activated sludge, which is also manually adjusted. When the amount of activated sludge wasted is changed, the feed rate of polyelectrolyte to the float thickener must also be changed to maintain the desired dosage.



NOTE:

BY MEANS OF THE SPARE FEEDER, POLYELECTROLYTE MAY ALSO BE FED, IF DESIRED, TO:

- (1) PLANT INFLUENT RISING WELL AHEAD OF PRIMARY CLARIFIERS.
- (2) RAPID MIX BASIN AHEAD OF CHEMICAL CLARIFIER.
- (3) PRIMARY RECARBONATION BASIN AHEAD OF REACTION BASIN.

THROUGH UNDERGROUND CHEMICAL FEED LINES PROVIDED FOR THIS PURPOSE.

FIGURE 65
POLYELECTROLYTE (SECONDARY FLOC) FEED TO SEPARATION BEDS

4. When two centrifuges are in use for dewatering biological sludge, it is anticipated that no chemicals will be required. When a single centrifuge is used at plant flows in excess of about 4 mgd, it may be necessary to use a polyelectrolyte as an aid to dewatering. The type and amount of polyelectrolyte to be used can only be determined by trial in actual plant operation.

Separate polyelectrolyte mixing and feed equipment is provided on the upper floor of the incineration building for application of polyelectrolyte directly into the two centrifuges handling biological sludge. This equipment consists of a mixing tank with mechanical agitator, a single feed pump, an eductor for adding dilution water, and a pair of rotameters for dividing the feed of polyelectrolyte solution to the two centrifuges.

The flow of sludge to the centrifuges is manually set at a constant rate. The polyelectrolyte feed, when used, is also manually adjusted by means of a variable speed control.

Alum. In the new plant, lime will replace alum as the primary coagulant which is added in the rapid mix basin ahead of the flocculator and chemical clarifier.

However, until the lime sludge dewatering and recalcining equipment is completed and placed into service, alum will continue to be used as the primary coagulant by addition of about 200 mg/l to the rapid mix basin. The dosage of alum is manually set by stroke adjustment, but may be paced to flow either from a signal derived from the Parshall flumes measuring plant inflow, or, by selection, from a signal measuring flow into the tertiary plant. Addition of alum to the rapid mix would be paced by the Parshall flume flow signal.

In normal operation of the new plant when lime is used as the primary coagulant, it probably will not be necessary to use alum. However, if the desired turbidity reduction is not obtained through the separation beds by lime and polyelectrolyte, then a small dose of alum to the water in the separation bed influent may be necessary. Alum feed to this point would be paced by selection of the tertiary plant influent flow signal.

As shown by Figure 66, alum may also be applied, if desired, to the raw sewage in the plant influent rising well to improve settling in the primary clarifiers, or to the influent to the primary recarbonation basin to improve settling in the reaction basin beneath the ammonia stripping tower. The alum feed to these points would be paced by the Parshall flume flow signal.

Liquid alum is stored in two tanks in the basement of the tertiary plant.

There are two alum feed pumps which discharge into a common header where dilution water is introduced. In the tertiary plany control room, there is a rotameter flow division panel for proportioning the total alum feed between the separation bed influent header and any other desired point of application (1. plant influent rising well, 2. rapid mix basin, or 3. primary recarbonation basin).

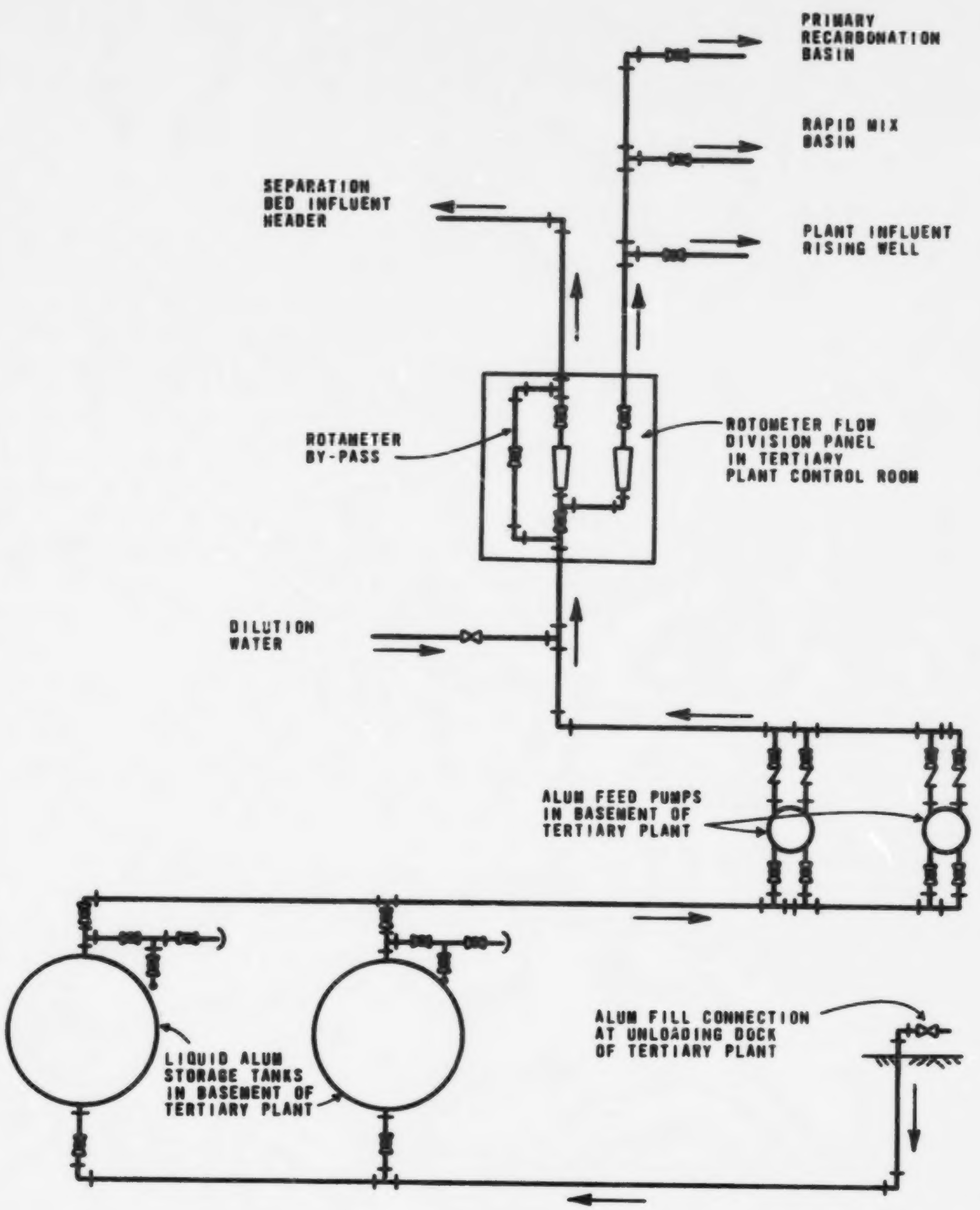

PRIMARY RECARBONATION BASIN
RAPID MIX BASIN
SEPARATION BED INFLUENT HEADER
PLANT INFLUENT RISING WELL
ROTAMETER BY-PASS
ROTOMETER FLOW DIVISION PANEL IN TERTIARY PLANT CONTROL ROOM
DILUTION WATER
ALUM FEED PUMPS IN BASEMENT OF TERTIARY PLANT
ALUM FILL CONNECTION AT UNLOADING DOCK OF TERTIARY PLANT
LIQUID ALUM STORAGE TANKS IN BASEMENT OF TERTIARY PLANT

FIGURE 66
ALUM APPLICATION

Carbon Dioxide. The source of carbon dioxide in the plant for use in recarbonation of the lime treated water is flue gas. When either the sludge incineration furnace or the lime recalcining furnace is operating, the flue gas will contain sufficient carbon dioxide for recarbonation. If both furnaces are out of operation, the afterburner on the upper hearth of the sewage sludge incineration furnace may be operated to furnish the required carbon dioxide (CO_2).

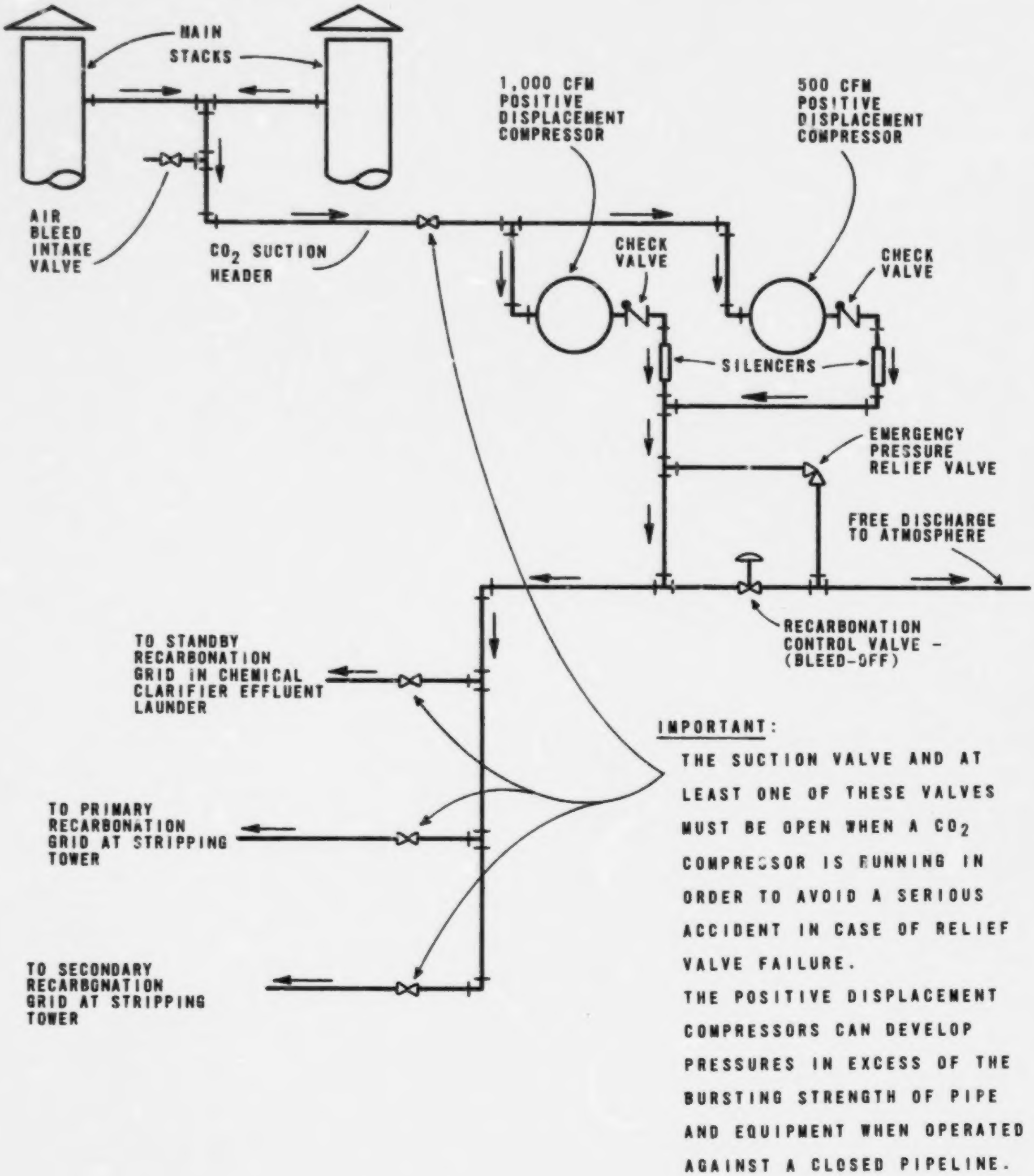
There are presently two positive displacement type compressors, one with a capacity of 500 cfm (cubic feet per minute) and another with a capacity of 1,000 cfm. The small blower should handle plant flows up to 2.5 mgd, and the large blower alone is adequate for flows up to 5 mgd. Both units will operate together for flows in excess of 5 mgd. In the future a third blower with a capacity of 1,500 cfm will be installed to provide complete standby capacity.

The compressors take suction from both of the main furnace stacks through a common line as shown by Figure 67. The suction line contains a shut-off valve for use only in case of repairs to the compressors or suction line. This valve MUST BE OPEN when either compressor is running. In the suction line there is also a manually-operated bleeder valve for admitting air to reduce the CO_2 concentration by dilution if necessary.

The compressed CO_2 normally is applied to the primary and secondary recarbonation basins at the stripping tower. The pH of the stripping tower effluent is about 11. The primary recarbonation should reduce the pH of the water to about 9.3, which is near the minimum solubility range for calcium carbonate. A pH of 9.3 in the reaction basin should yield maximum calcium recovery. The purpose of secondary recarbonation is to stabilize the effluent and to minimize deposition of calcium carbonate in pipelines, filters, and carbon columns, and also to conform to discharge requirements which will require secondary recarbonation to pH 8.5.

Standby single-stage recarbonation is provided in the effluent launder of the chemical clarifier. Here the pH of the wastewater is reduced from 11 to 8.5 in a single step.

The compressors discharge through check valves and silencers into a common header. This header is fitted with an emergency pressure relief valve and an automatic recarbonation control valve, both of which discharge to free atmosphere. There are three isolation valves on the compressor discharge, one on the feed line to the standby recarbonation grid, and one each on the primary and secondary recarbonation grids at the ammonia stripping tower. Normally the valve to the standby grid would be closed, and the two valves to the primary and secondary grids would be open.


MAIN STACKS
1,000 CFM POSITIVE DISPLACEMENT COMPRESSOR
500 CFM POSITIVE DISPLACEMENT COMPRESSOR
AIR BLEED INTAKE VALVE
CO_2 SUCTION HEADER
CHECK VALVE
CHECK VALVE
SILENCERS
EMERGENCY PRESSURE RELIEF VALVE
FREE DISCHARGE TO ATMOSPHERE
RECARBONATION CONTROL VALVE - (BLEED-OFF)
TO STANDBY RECARBONATION GRID IN CHEMICAL CLARIFIER EFFLUENT LAUNDER
TO PRIMARY RECARBONATION GRID AT STRIPPING TOWER
TO SECONDARY RECARBONATION GRID AT STRIPPING TOWER

IMPORTANT:

THE SUCTION VALVE AND AT LEAST ONE OF THESE VALVES MUST BE OPEN WHEN A CO_2 COMPRESSOR IS RUNNING IN ORDER TO AVOID A SERIOUS ACCIDENT IN CASE OF RELIEF VALVE FAILURE.

THE POSITIVE DISPLACEMENT COMPRESSORS CAN DEVELOP PRESSURES IN EXCESS OF THE BURSTING STRENGTH OF PIPE AND EQUIPMENT WHEN OPERATED AGAINST A CLOSED PIPELINE.

FIGURE 67
RECARBONATION
SCHEMATIC

It is very important to note that at least one of these valves must be open whenever a CO_2 compressor is running in order to avoid a serious accident in case of a relief valve failure. The positive displacement compressors can develop pressures in excess of the bursting strength of pipe and equipment when operated against a closed pipeline. Before a CO_2 compressor is started, the operator MUST check the recarbonation isolation valves to be certain that at least one isolation valve is open, and that the suction valve is open.

Detailed operation and control of the recarbonation system is covered later in this manual.

ACTIVATED CARBON TREATMENT

Contained herein is a description of the purpose of activated carbon treatment, the details of carbon transfer, and the theory and practice of carbon regeneration at the South Tahoe PUD Water Reclamation Plant.

Purpose of Activated Carbon. The purpose of the granular activated carbon is to remove detergents (ABS) and various organic materials which contribute to the taste, odor, and color of sewage. These materials are removed from the waste water by a process called adsorption, leaving an effluent which is sparkling clear.

Since the carbon is removing organic materials from the water, it is logical that the carbon will increase in weight, as all the organic materials removed have weight. With continual use, the carbon will become saturated with organic materials and will lose its ability to remove organic materials. In order to maintain a sparkling clear effluent, the saturated or spent carbon is removed from the bottom of the column and replaced with fresh or regenerated carbon at the top.

Carbon Transfer. Carbon is transferred from one container to another within the plant in a water slurry. In each case, the operation consists of providing more than enough transfer water to move a concentrated carbon slurry through the pipes without pluggage, and then adding the carbon to this transfer stream. A detailed description of each transfer operation follows.

I. From Columns to Dewatering Bins

A. Check valve positions on blue transfer line.

B. Turn on and regulate transfer water (Valve A, Figure C-1),

C. With columns on stream, turn on No. 3 water to the transfer header at the base of the column side wall (Valve B).

D. Open wafer valve at bottom of column (Valve C).

E. After transferring desired amount of carbon, close wafer valve.

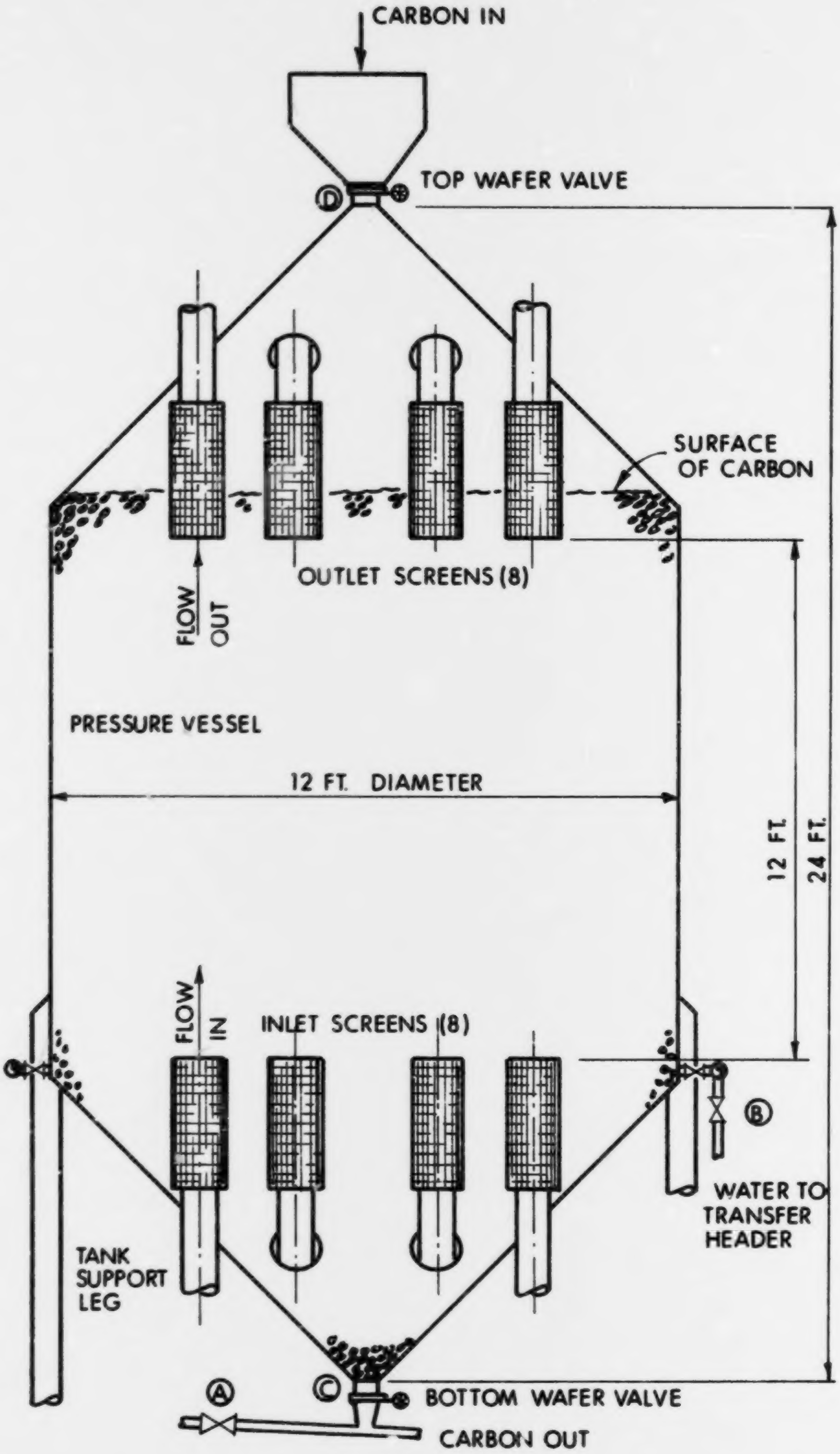
F. Turn off No. 3 water to transfer header (Valve B).

G. After transfer line has been flushed clear, shut off transfer water (Valve A).

II. From Carbon Storage Bins or Furnace

A. Check valve positions on transfer line.

B. Open intake and discharge valves to appropriate slurry pump and close valves on alternate pump.



SECTION THRU CARBON COLUMN

FIGURE C-1

C. Turn on and regulate transfer water to pump (Figure C-2).

D. Turn on air supply to pump.

E. Turn on power switch for slurry pump.

F. Control carbon transfer rate by means of cycle control timer.

G. After transfer is complete, turn off pump control power.

H. After transfer line has been flushed, turn off air and water.

III. From De-fining Tank to Column

A. Check valve positions on black transfer line.

B. Take column off stream by closing influent valve and diverting flow to other columns or to waste.

C. Open top wafer valve (D) on carbon column.

D. Close top wafer valve (E, Figure C-3) and drain valve (F) on de-fining tank.

E. Pressurize de-fining tank by opening 2-inch valve (G) on side of tank.

F. Turn on and regulate transfer water (Valve H).

G. Open bottom wafer valve (I) on de-fining tank.

H. After carbon transfer, close bottom wafer valve (I).

I. After transfer line has been flushed clear, shut off transfer water (Valve H).

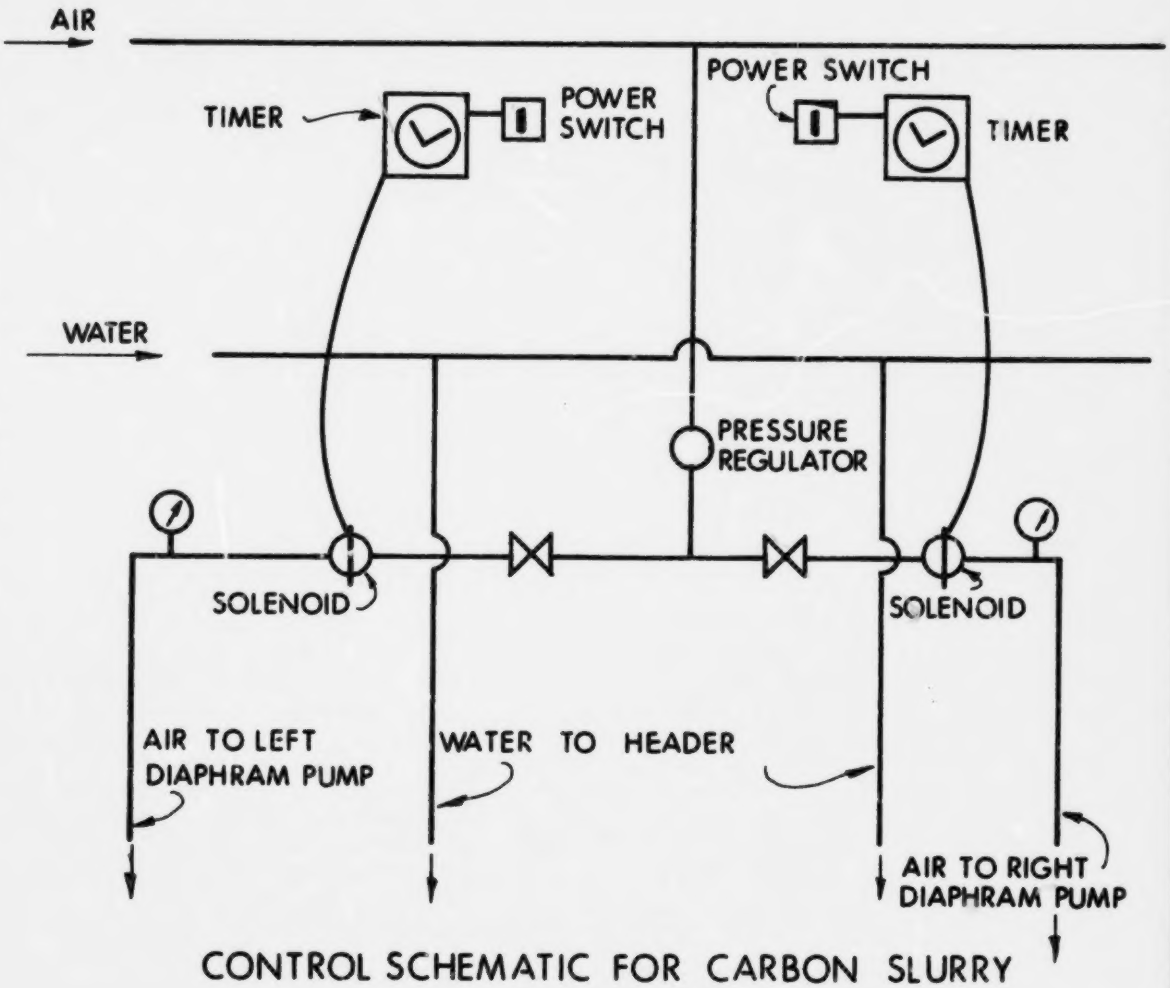
J. Close pressurizing Valve (G).

K. Open drain valve (F).

L. Close top wafer valve on carbon column (D) and place column back on stream.

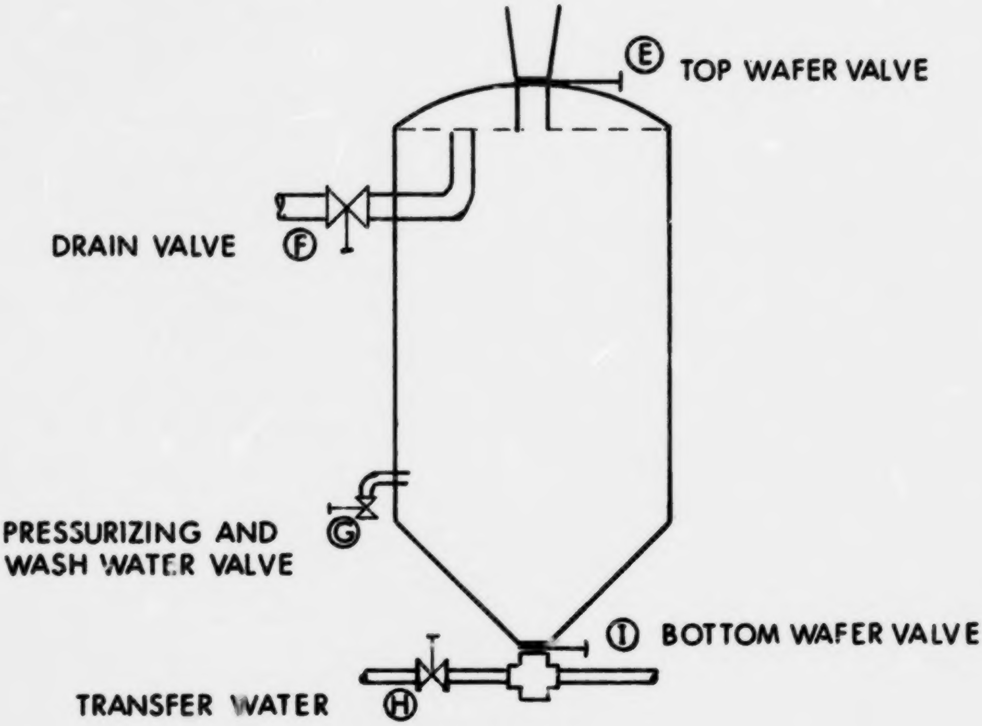
Carbon Regeneration.

Theory of Carbon Regeneration: The spent carbon or carbon which is saturated with organic materials can be regenerated or reactivated by heating the carbon to a high temperature. At high temperatures (namely 1650-1680 degrees F.) and in a stream atmosphere, the organic materials in the carbon are volatilized and discharged from the furnace in the stack



CONTROL SCHEMATIC FOR CARBON SLURRY PUMPS

FIGURE C-2



CARBON DE-FINING TANK

FIGURE C-3

gas. In practice, however, these gases are combustible and are burned inside the furnace before leaving the furnace. The regenerated carbon, which comes out of the furnace, is essentially free of organic materials and is capable of removing as much organic material from the waste water as is new or virgin carbon.

Control of Carbon Regeneration. As previously mentioned, the activated carbon increases in weight as it becomes saturated with organic material. As the carbon is regenerated, the organics are removed from the carbon, and as a result the carbon loses weight. Since weighing a given volume of carbon is a fast and simple test, the regeneration process is controlled by determining the apparent density of the carbon. The procedure for determining the apparent density of carbon follows. The apparatus described is pictured in Figure C-5.

Apparent Density Test for Activated Carbon.

I. Weigh the 100 ml graduate cylinder supplied with the carbon shaker apparatus and record the weight in grams. (Weigh on trip balance).

II. Pour a sufficient amount of the carbon to be tested into the funnel at the top of the shaker, place the graduated cylinder under the shaker, and fill to the 100 ml mark.

Note: The shaker should be adjusted so that the carbon fills the graduate cylinder at approximately 1 ml per second.

III. Weigh the graduate cylinder and carbon and record the weight in grams.

IV. To calculate the apparent density, determine the weight of carbon in the full graduate and divide by 100.

$$\text{Weight Carbon} = \begin{matrix}\text{Weight Full}\\ \text{Graduate}\end{matrix} - \begin{matrix}\text{Weight Empty}\\ \text{Graduate}\end{matrix}$$

$$\text{APPARENT DENSITY} = \frac{\text{Weight Carbon}}{100}$$

V. Example

Weight Empty Graduate = 128.0 gm

Weight Full Cylinder = 176.6

Weight Carbon = 176.6-128.0 48.6

$$\text{APPARENT DENSITY} - \frac{48.6}{100} = \quad 0.486 \text{ gm/ml}$$

The apparent density of the spent carbon being regenerated has been found to vary between 0.50 to 0.52. The apparent density of the virgin carbon is 0.48. However, the spent carbon is regenerated to an apparent density varying from 0.48 to 0.59. If the apparent density

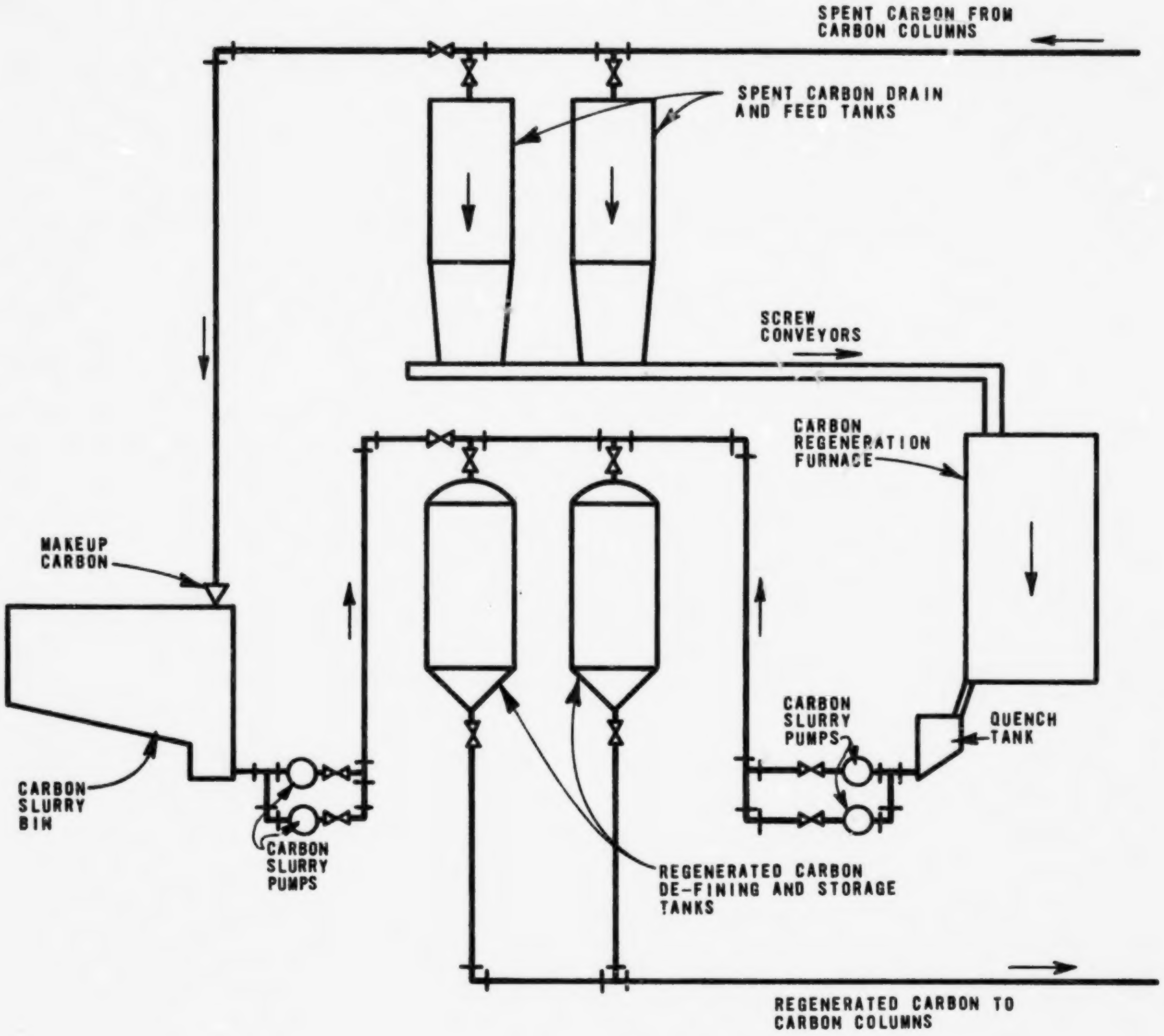
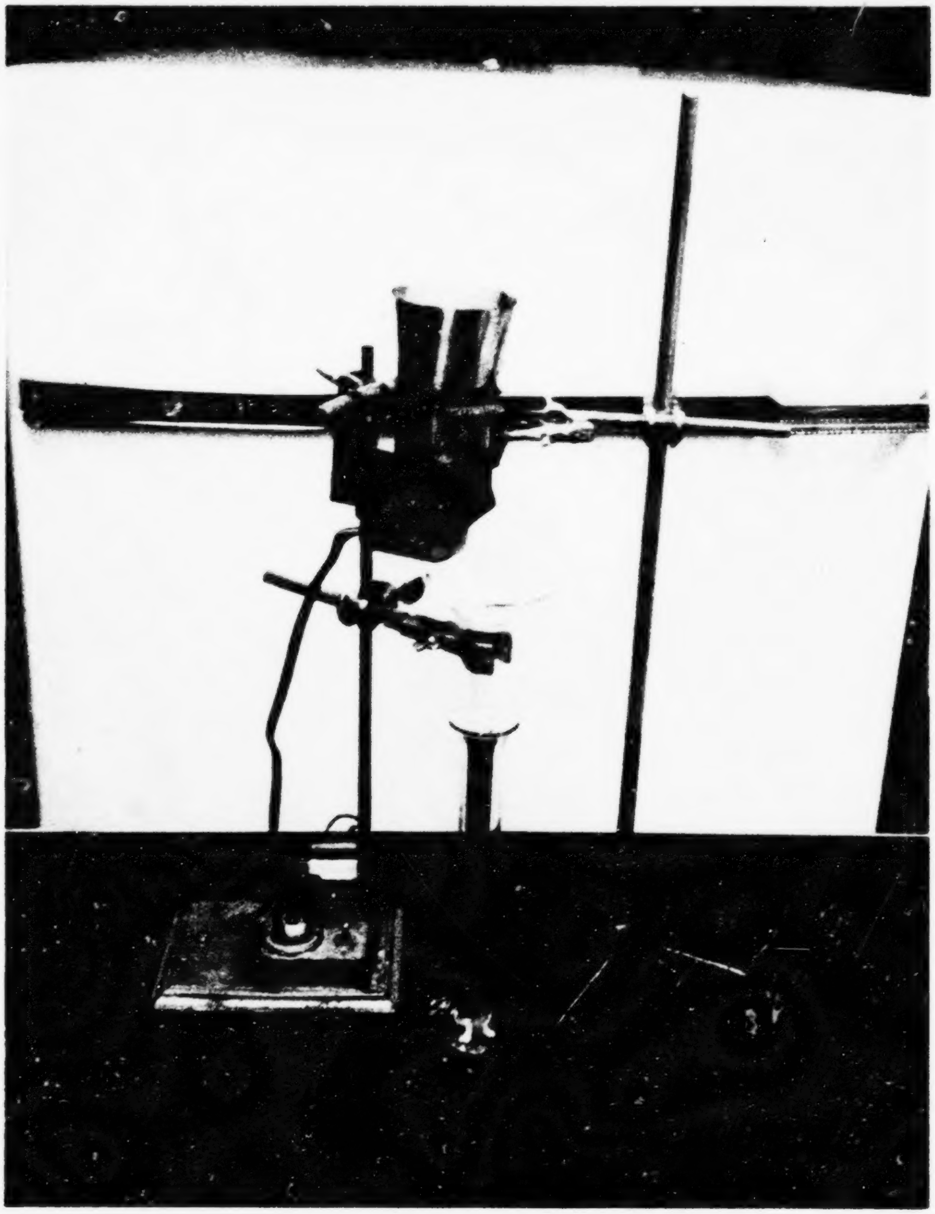

SPENT CARBON FROM CARBON COLUMNS
SPENT CARBON DRAIN AND FEED TANKS
SCREW CONVEYORS
CARBON REGENERATION FURNACE
MAKEUP CARBON
CARBON SLURRY BIN
CARBON SLURRY PUMPS
CARBON SLURRY PUMPS
QUENCH TANK
REGENERATED CARBON DE-FINING AND STORAGE TANKS
REGENERATED CARBON TO CARBON COLUMNS

FIGURE C-4

CARBON REGENERATION SYSTEM



APPARATUS FOR DETERMINING THE APPARENT DENSITY OF GRANULAR ACTIVATED CARBON

FIGURE C-5

is greater than 0.49, the carbon is not obtaining enough heat to volatilize a sufficient quantity of organic material. On the other hand, if the apparent density is less than 0.48, the carbon is obtaining too much heat, and carbon is being burned in the furnace.

The apparent density (A.D.) of the regenerated carbon can be varied by changing the following process variables:

1. Temperature is the most critical factor in carbon regeneration; a higher temperature will give a lower A.D. and a lower temperature will give a higher A.D. Never change the temperature more than 20 degrees F. while regenerating carbon.

2. Carbon feed rate is the next critical factor in carbon regeneration. Increasing the carbon feed rate will reduce the contact time in the furnace and the amount of heat supplied to the carbon and will give the carbon a higher A.D. Lowering the carbon feed rate will increase the contact time in the furnace and the amount of heat supplied to the carbon and will give the carbon a lower A.D.

3. Steam provides more energy for carbon regeneration. Increasing the steam feed rate will decrease the A.D. Decreasing the steam feed rate will increase the A.D.

4. Furnace drive speed regulates the depth of carbon on the furnace hearths. Increasing the drive speed will decrease the carbon depth, and decreasing the drive will increase the carbon depth. In practice, this is not as critical as temperature and carbon feed rate.

Do not change more than one process variable per half-hour interval.

Operation of Carbon Regeneration Furnace. Following is a sequential list of procedures for starting and stopping the carbon regeneration furnace.

Carbon Furnace Start Up

1. Check lubrication of all mechanical equipment associated with the carbon regeneration furnace.

2. Check sand seals at top and bottom of furnace.

3. Check inspection doors and make interior visual check with furnace shaft running (One bolt only tight on each door).

4. Remove U.V. Flame Scanner (Purple Peeper) and clean glass with Clean Lens tissue.

5. Check to see that carbon discharge sludge gate is open.

6. Fill quench tank with water to provide a water seal on the discharge chute. Also, read and record gas meter readings.

7. Check to see that all burner gas and air valves are closed.

8. Check to see that pilot light gas valves are open.

9. Open main gas valve by gas meter.

10. Manually close damper.

11. Turn on scrubber water supply (5 to 10 psi).

12. Turn panel power on.

13. Start draft fan.

14. Manually open damper to minus .05 inches draft and leave operator set in the manual position; do not place on automatic control.

15. Start furnace drive, shaft cooling air and combustion air.

16. After draft purged light comes on, push pilots - start button.

17. Bring furnace up to a temperature of 300 degrees to 350 degrees with pilot lights.

18. Place damper control on automatic set at .05 inches minimum. This can fluctuate to as high as 0.2 inches draft.

19. Open gas valve fully on No. 1 burner. Open manual air valve approximately 1/4 turn.

20. Open (slowly) the two safety gas valves on furnace.

21. Push low fire button. Allow temperatures to rise at a rate not to exceed 100 degrees F. per hour (except for initial sharp rise). Rate of temperature increase can be controlled by manually operated air valves.

22. When rate of temperature increase drops below 50 degrees F. per hour, turn on burner No. 4 at same valve settings as No. 1.

23. When rate of temperature increase again drops below 50 degrees F. per hour, turn on burners No. 2 and No. 3 at same valve settings.

24. The furnace burners can also be put on Automatic Control (high fire) at this time.

25. Bring furnace up to 1600 degrees F. using automatic controls at a rate not to exceed 100 degrees F. per hour.

26. Start feeding carbon, using proper carbon regeneration procedures.

27. Set manual air valves so that the two automatic control valves will be operating in their lower middle range so that automatic control system will function properly.

Carbon Furnace Shutdown

1. Set carbon screw conveyor to low speed (1) on dial.

2. Close burner manual air valves to approximately 1/8 open position.

3. Stop carbon feed.

4. Reduce furnace temperatures with the automatic controllers at a rate not to exceed 100 degrees F. per hour.

5. After temperatures have stabilized and can no longer be reduced with the automatic controller, close gas and air valves on burners No. 1 and No. 4.

6. Shut off steam if it has been on.

7. Continue dropping furnace temperatures using automatic controllers at the usual rate not to exceed 100 degrees F. per hour.

8. When use of automatic controls will not drop temperatures any lower, at the desired rate, push low fire button and reduce manual air valve setting on burner No. 3 by 1/2 of present settings.

9. Further reduce furnace temperatures by shutting off manual air valve No. 3 and gas valve No. 3.

10. Burner No. 2 manual air valve to be set at 1/2 of present position ultimately shut off.

Note: Steps 8, 9, and 10 - temperature drop not to exceed 100 degrees F. per hour.

11. When desired temperature decrease of 50 degrees F. to 100 degrees F. is not maintained - shut off. Main gas valve, which will automatically shut off pilot lights. Also shut off combustion air blower.

12. Take and record gas meter readings.

13. When furnace temperatures drop below 800 degrees F., shut off draft fan.

14. When furnace temperatures drop below 500 degrees F., shut off shaft cooling fan.

15. At 300 degrees F. shut off scrubber water, furnace drive and power panel.

Furnace Malfunctions. There are several safety features on the furnace which will shut the furnace down. Attention should be given to the following items in the event the furnace experiences a nonroutine shut down:

1. Purple Peeper.
2. High (more than 16 oz./sq. in.) or Low (less than 8 oz./sq. in.).
3. No Combustion Air.
4. No Draft Fan.
5. Low Scrubber Water Pressure.
6. Furnace drive inoperative. In addition, if the furnace drive stops, the screw conveyors will automatically be stopped.
7. High Furnace Temperature.
8. High Stack Gas Temperature.
9. No Shaft Cooling Air.

Carbon De-Fining. All regenerated carbon and virgin carbon should be de-fined prior to its addition to a carbon column. This is necessary in order to reduce headloss problems within the column. A description of the de-fining procedure follows:

Carbon De-Fining Procedure

A. Fill the de-fining tank to about half full of carbon.

B. Close top wafer valve (E, Figure C-3) on the de-fining tank.

C. Open 2-inch wash water valve (G) on side of tank.

D. Open drain valve (F).

E. Check samples taken from drain line for carbon fines.

F. Shut wash water valve (G) when no more carbon fines are present in the samples from the drain line.

SOLIDS HANDLING

Primary and Secondary Sludge. As shown by Figures 29 through 34, a mixture of waste activated sludge which has been partially dewatered in a floatation thickener and raw primary sludge is pumped to the incineration building. This sludge mixture will contain not less than 3.5% solids. When necessary for proper dewatering in the centrifuges, polyelectrolyte is added to the sludge mixture as it enters the centrifuges. When only one heavily loaded centrifuge is in use, the polyelectrolyte may be needed otherwise, it probably will not be required.

The handling of the primary and secondary sludge mixture within the incineration buidling is shown on Figure 68. No. 2 centrifuge is always used for dewatering sewage sludge. No. 3 centrifuge is normally used for sewage sludge, but also serves as a standby unit for dewatering lime sludge. The centrate, or waste water, from the centrifuges is returned through a drain line to the primary clarifier influent channel in the old primary building. The dry sludge cake (about 80% moisture) drops on to a reversible conveyor belt which will discharge either to the sewage sludge incineration furnace, or, if the furnace is not operating, to a chute for truck loading. The sludge is incinerated within the furnace. The ash is conveyed by a bucket elevator to a screw conveyor and an ash storage bin. The ash storage bin is equipped with a bottom screw conveyor and water spray for dust control during truck loading. At plant flows of 7.5 mgd about 10 tons of ash per day will be produced by sewage sludge incineration.

The operation, maintenance, and control of the sludge handling equipment is discussed in detail later in this manual.

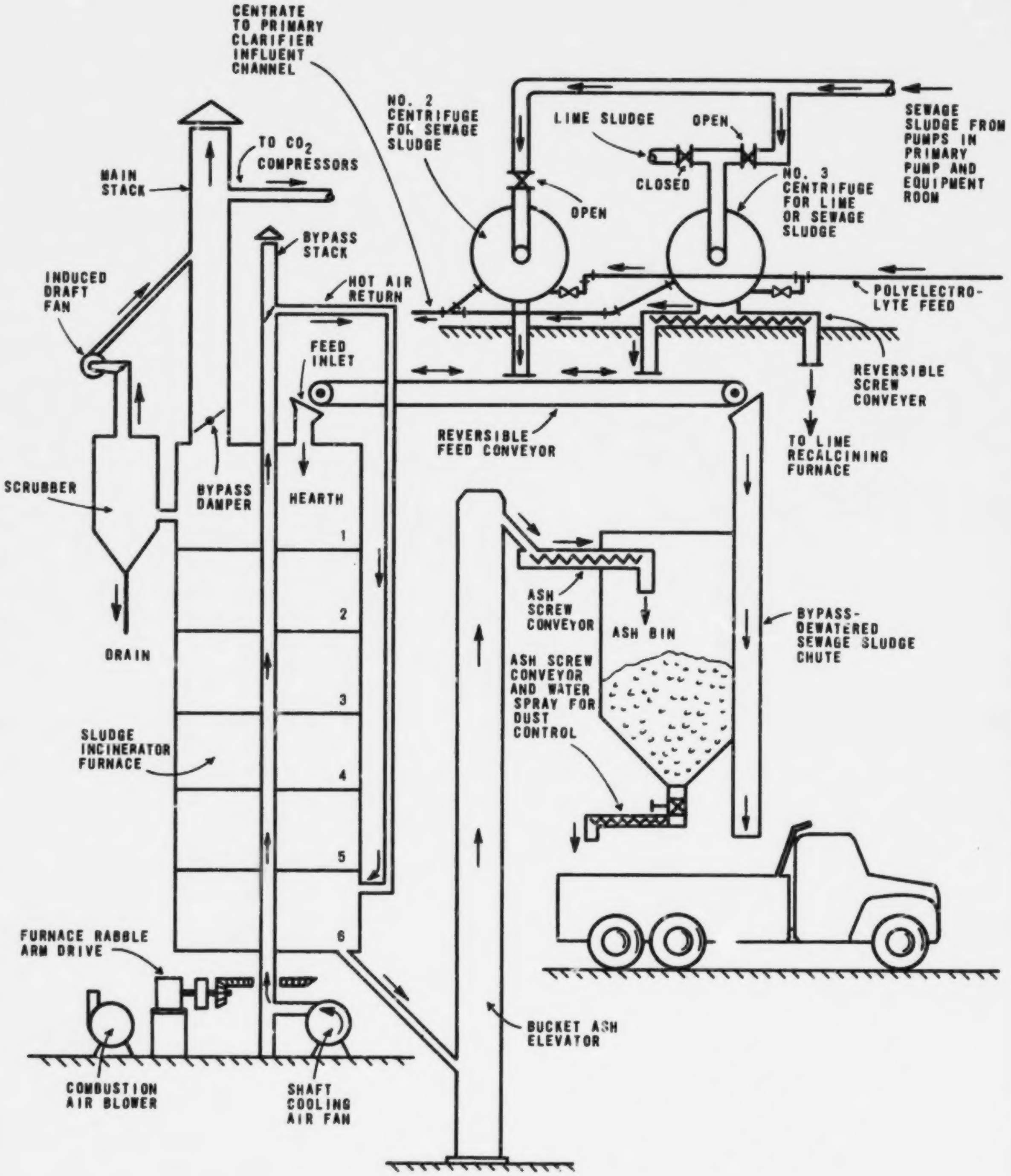

CENTRATE TO PRIMARY CLARIFIER INFLUENT CHANNEL
NO. 2 CENTRIFUGE FOR SEWAGE SLUDGE
LIME SLUDGE
OPEN
CLOSED
OPEN
NO. 3 CENTRIFUGE FOR LIME OR SEWAGE SLUDGE
SEWAGE SLUDGE FROM PUMPS IN PRIMARY PUMP AND EQUIPMENT ROOM
TO CO_2 COMPRESSORS
MAIN STACK
BYPASS STACK
INDUCED DRAFT FAN
HOT AIR RETURN
POLYELECTROLYTE FEED
FEED INLET
REVERSIBLE SCREW CONVEYER
REVERSIBLE FEED CONVEYOR
TO LIME RECALCINING FURNACE
SCRUBBER
BYPASS DAMPER
HEARTH
1
2
3
4
5
6
ASH SCREW CONVEYOR
ASH BIN
BYPASS-DEWATERED SEWAGE SLUDGE CHUTE
DRAIN
ASH SCREW CONVEYOR AND WATER SPRAY FOR DUST CONTROL
SLUDGE INCINERATOR FURNACE
FURNACE RABBLE ARM DRIVE
BUCKET ASH ELEVATOR
COMBUSTION AIR BLOWER
SHAFT COOLING AIR FAN

FIGURE 68
SOLIDS HANDLING
PRIMARY AND SECONDARY SLUDGE

Chemical Sludge.

Alum Sludge. When alum is used as the primary coagulant in the rapid mix basin, the alum sludge settles out in the chemical clarifier and is pumped by the units in sludge recirculation pump station No. 1 to the new primary clarifier where it again settles out and is pumped along with the primary sludge to the sewage sludge incinerator where it is burned to ash. See Figures 14, 54, 37, and 68.

Lime Sludge. When lime is used as the primary coagulant most of the lime sludge is collected in the chemical clarifier. The lime sludge collected here originates from the application of lime to the rapid mix and from the discharge of lime sludge to the rapid mix basin out of the backwash water decanting tank (see Figures 52 and 53). Lime sludge from the chemical clarifier passes to sludge sump No. 2 in sludge recirculation pump station No. 1 (see Figure 14). Sludge sump No. 2 also receives sludge from the sludge sump in the reaction basin at the ammonia stripping tower. From sludge sump No. 2, the lime sludge is pumped to the lime mud thickener.

From the lime mud thickener, the lime sludge (which contains about 8% solids) is pumped by either or both of two variable speed spent lime pumps located in the basement of the incineration building to the centrifuges for further dewatering, (see Figure 69). Normally centrifuge No. 1 would be used for dewatering lime sludge. No. 3 centrifuge is available for standby service in dewatering lime sludge, although it is normally used for sewage sludge. The dry lime sludge cake drops to a reversible conveyor belt which will discharge into the lime recalcining furnace, or, if the furnace is not operating, to the dewatered lime sludge storage bin for truck loading. The spent lime sludge is recalcined within the furnace. The recalcined lime is cooled in a thermal disc cooler and conveyed pneumatically to the recalcined lime storage bin, or if this bin is out of service, to the fresh makeup lime bin. The recalcining furnace will produce a maximum of about 20 tons of lime per day.

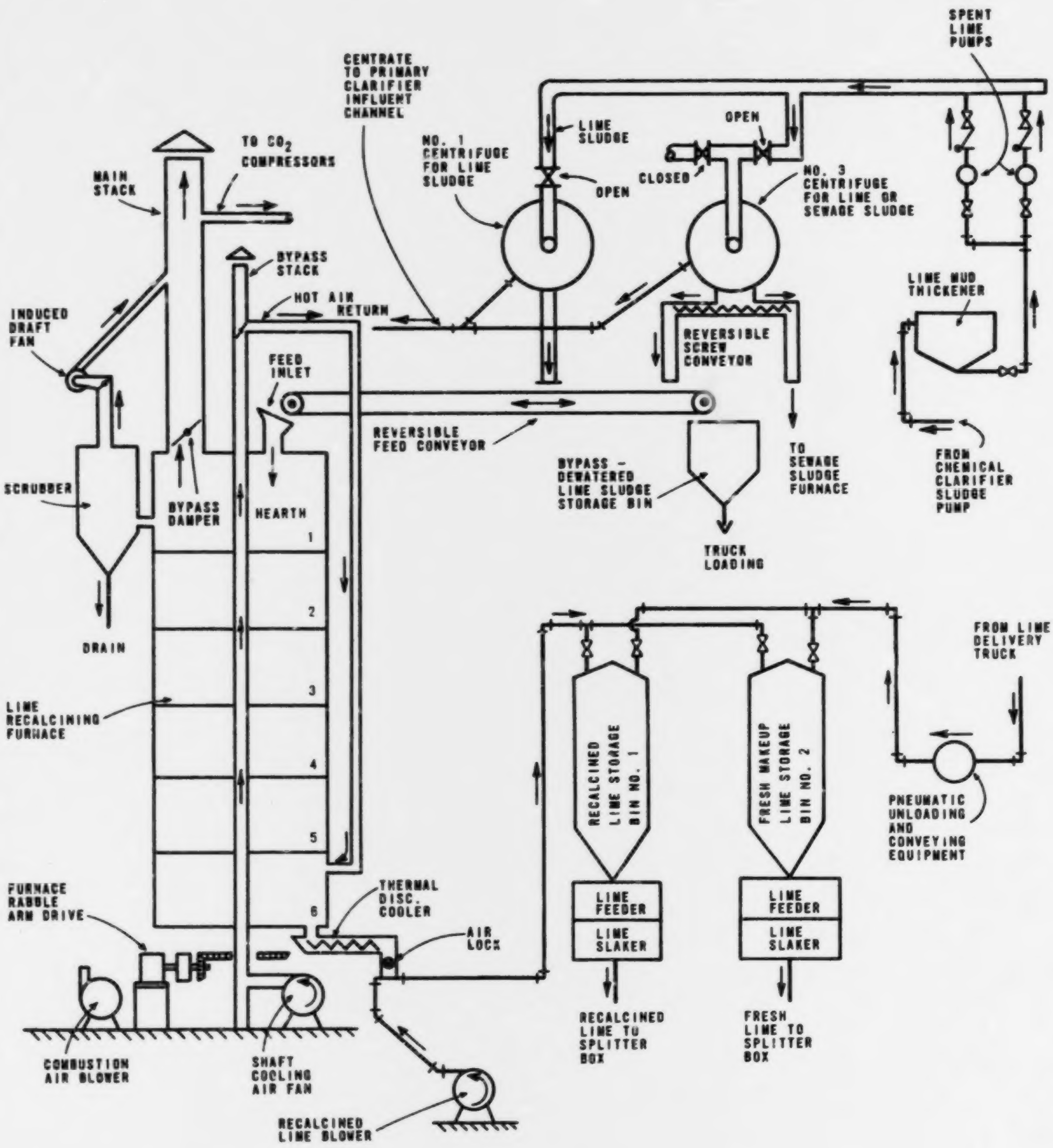


FIGURE 69
SOLIDS HANDLING
LIME SLUDGE

EMERGENCY OPERATION

Electric Power Outage. The capacity of the existing standby electric generator at the plant is about 250 kva. The items connected to the emergency generating panel are as follows:

1. Secondary effluent pump No. 1 (75 hp) (Discharging to 60 mg holding pond)
2. Carbon furnace - shaft cooling air fan
3. Sludge furnace - shaft cooling air fan
4. Lime furnace - shaft cooling air fan
5. Barminutor No. 1
6. Barminutor No. 2 (3 hp)
7. Deep well pump
8. Plant drain pump No. 1
9. Plant drain pump No. 2
10. Incinerator building duplex sump pumps (4 hp)
11. Control transformer
12. Lighting transformer
13. Lighting panels A, B, & C
14. Outside lighting panel
15. Control building heating and ventilating panel
16. Control building air supply fan
17. Control building ground detector system
18. Air compressor No. 1
19. Air compressor No. 2
20. Hypochlorite feeder

For any power outage of more than a few minutes duration, the first change to be made in the mode of plant operation is to place the secondary and final effluent pump stations into operation as shown by Figure 39. During a power outage, the only pump available for service is secondary effluent pump No. 1 which is connected to the emergency generator. As shown by Figure 39, during the power outage secondary effluent pump No. 1 would be used to pump secondary effluent to the emergency 60 million gallon storage pond.

During the power outage the activated sludge air blowers, the mechanical aerators, and the sludge pumps are out of service. Also the tertiary plant, chemical feeders, and incineration equipment are out of service.

When normal power is restored, the plant can be returned to the mode of treatment which was in use before the failure occurred.

Once the treatment plant is back in normal operation, it is desirable to return the secondary effluent stored in the emergency 60 million gallon pond to the plant for tertiary treatment and export. The method of doing this is shown on Figure 47. When this is done care must be taken (1) to throttle the rate of return flow from the 60 million gallon pond into ballast pond No. 1 to prevent overflow of the secondary effluent pump station wet well into the final effluent pump station wet well, and (2) to increase the amount of alum feed to the separation bed influent as necessary to properly clarify the mixture of normal plant flow and return flow from the pond.

The method of placing the emergency power generator in service, and the methods for restarting the various pieces of plant equipment and restoring the different treatment units to service are described in sections of this manual which follow.

Natural Gas Off. The natural gas service to the treatment plant is on an interruptible basis. That is, in times of high demand for natural gas in the Tahoe area, the gas company has the right to temporarily interrupt service to the plant. Ordinarily, notice would be given a day or so in advance by the gas company, who might also give an estimate of the probable duration of the shutdown.

The principal items affected by such an interruption are the carbon, lime, and sludge furnaces. The lime and sludge furnaces are quite readily switched from natural gas to the standby propane system. Switching fuel to the carbon furnace is more difficult, so that if the natural gas supply interruption is expected to be something less than two weeks, it should be possible to shutdown operation of the carbon furnace in the normal manner and to discontinue its operation during the time the standby propane fuel is in use.

After the natural gas is turned off the propane vaporizer and blender are placed into operation. At this point, check all pilot lights and relight if necessary. The lime and sludge furnaces can then be started burning propane with no other changes.

In the event that operation of the carbon furnace on the propane-air mixture is necessary the detailed procedure for making the necessary furnace adjustments is given later in this manual.

PROCESS

Primary Treatment (Solids Separation).

General. The objectives of primary treatment are (1) prechlorination for odor control; (2) grinding or shredding of large solids into smaller size in order to protect pumps and equipment; (3) removal of floatable materials and scum; (4) the removal of a portion of the phosphate content of the raw sewage; (5) the removal of a portion of the BOD content of the raw sewage; (6) the removal and concentration of the major fraction of settleable solids contained in the raw sewage; and (7) the orderly withdrawal for further treatment of all settleable solids collected in the two primary clarifiers.

In order to accomplish these objectives, operators will use the following equipment.

(2)	36-inch sewage grinders (Barminutors)
(1)	Emergency hand cleared bar screen
(2)	Parshall flumes for sewage flow control during normal operation
(1)	Bypass channel for use during abnormal operation in the event that one Barminutor is out of operation and the remaining machine cannot handle the flow being received
(2)	Primary clarifiers with sludge and scum collection equipment
(4)	Sludge transfer pumps, positive displacement, piston type

In addition to the above mechanical equipment, operators must select and properly use various stop logs and slide gates in order to route the raw sewage flow through the desired equipment.

Figures 3, 4, 5, and 6 show the various flow routing combinations available and indicate the proper stop log and slide gate settings for any combination of primary clarifiers in or out of service. In the event that one or both Barminutors are out of service, it is still possible to operate both primary clarifiers if desired by throttling the slide gate which controls influent to Primary Clarifier No. 1. IMPORTANT - The chief operator must always be consulted before attempting to throttle influent to Primary Clarifier No. 1 as it is possible to cause overflow of the main influent channel by improper manipulation of the various gates.

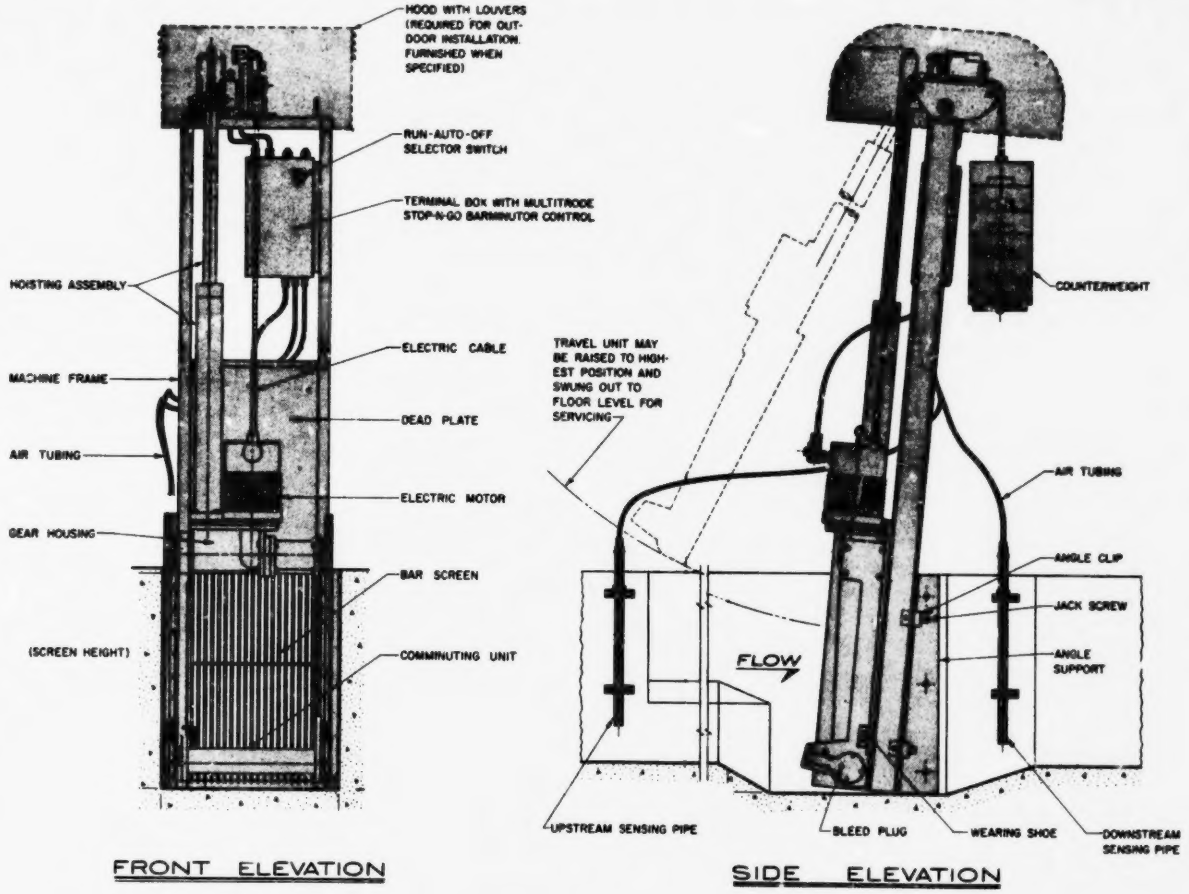
Prechlorination. Raw sewage enters the plant through various force mains which discharge into a rising well located adjacent to Primary Clarifier No. 1.

Since some of the sewage force mains are relatively long in length, part of the plant inflow may be septic; and it is quite likely that at times, odors caused by the septic condition of the influent will prevail. For this reason, facilities are provided to prechlorinate the raw sewage in the rising well. The exact amount of chlorine required to suppress odors can only be determined by experience. Dosages of from 20 to 50 pounds of chlorine per million gallons of sewage should be sufficient unless the sewage is extremely septic. Care must be taken not to feed large excesses of chlorine because this action would adversely affect the operation of the biological secondary treatment portions of the plant.

Screening and Sewage Grinding. After passage through the rising well, raw sewage is diverted to any or all of three separate channels as shown on Figures 3 through 6. Normally, the two channels which are equipped with Barminutors will receive the entire flow. The Barminutors are provided for the purpose of shredding or grinding large solids and stringy materials into smaller size so as to reduce the possibility of their plugging of sludge lines or pumps.

Both Barminutors are 36 inches in width and consist of an inclined set of vertical bars and a rotating set of cutters which travel up and down the inclined bars cutting and shredding solids caught by the bars. Each Barminutor is equipped with an automatic device which senses sewage levels in the channel upstream and downstream of the unit. This control automatically causes the device to operate whenever the inclined bars collect sufficient solids to impede the flow of sewage through the bars. After operating for a period of time, the machine then shuts itself off when sewage flow through the now cleaned inclined bars is unimpeded. A three-position selector switch mounted on the upper frame of each machine is used to control the operation of the Barminutors. In the "Off" position the machine is de-energized. In the "Auto" position the machine operates automatically as required, and in the "Run" position, the machine operates continuously. In addition to these selector switches, a two-position selector switch for each machine is provided in panel No. 34 of the instrumentation panel in the operations building. These switches, when in the "Off" position, de-energize the machine regardless of the setting of the switch on the machine and in the "Run" position energize the machine if the machine-mounted switch is set either at "Auto" or "Run". Both Barminutors are electrically interlocked to the emergency power system and if switched in the "Run" or "Auto" position will continue to operate regardless of failure of the primary power source.

Figure 70 shows typical front and side elevation views of the two Barminutors. Reference should be made to the detailed operating and maintenance instructions supplied by the manufacturers for items not covered in this manual.



FRONT ELEVATION

SIDE ELEVATION

FIGURE 70

PRIMARY TREATMENT-BARMINUTORS

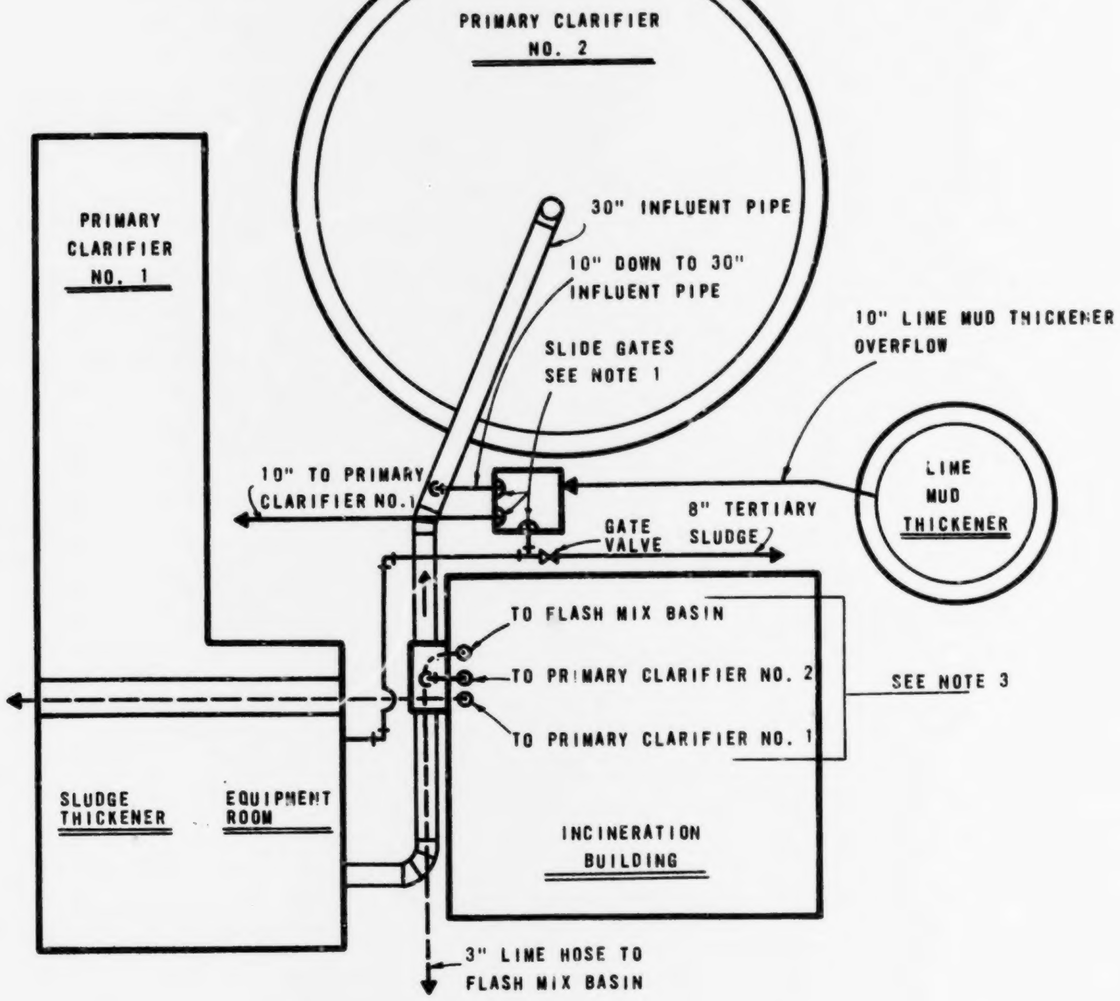
Chemical Feed. A portion of the total lime feed for chemical treatment and phosphate removal is to be applied to the screened raw sewage prior to its discharge to the two primary clarifiers. Two main purposes are served by lime fed in this manner. These are: (1) a large part of the soluble phosphates may be removed easily by this method, thus lightening the applied phosphate load on succeeding treatment stages; and (2) this method provides a convenient place to provide the required "blow down" of lime which is "phosphate poisoned" (i.e. chemically bound with PO_4^{-3} ions and thus not all reusable). Lime which is fed to the primary clarifiers and settles with primary sludges does not recycle to the lime recovery system but instead is desposed of along with the raw and biological sludges. This results in economy of lime recovery operations since it continuously and automatically disposes of the portion of lime most heavily "phosphate poisoned."

The lime which is fed to the primary clarifiers is produced as a milk-of-lime solution by the lime feeders and slakers located in the incineration building. Normally, only recalcined lime is fed to the primary clarifiers. Feed rate to the primary clarifiers is controlled by an automatic system which senses the pH of the primary clarifier overflow and feeds sufficient recalcined lime to maintain this pH at approximately 9.3. Care must be taken that the pH is not allowed to exceed 9.3 appreciably since higher pH values might adversely affect the operation of the activated sludge system which follows primary treatment.

The entire lime supply to be fed to both primary clarifiers is introduced into a lime splitter box located in the incineration building. This splitter box, shown on Figure 64, is equipped with weirs and separate lime solution discharge hoses for each required point of lime feed. Operation and control of this device are more fully discussed elsewhere in this instruction manual; however, in discussing the operation of primary clarifiers, it should be noted that at any time either or both primary clarifiers are taken out of operation, the lime solution hose feeding such clarifier(s) must be plugged. Removable threaded plugs for this purpose are provided as a part of the lime splitter box.

Figure 71 shows a schematic piping diagram which indicates the feed piping provided to introduce lime feed into the primary clarifiers.

Overflow from the lime mud thickener is discharged to either or both primary clarifiers. This discharge serves no useful purpose in the overall operation of the plant but is required since the thickener overflow requires retreatment and this can be accomplished most readily by discharge to the primary clarifiers. Normally, all of the lime mud thickener overflow should be directed to Primary Clarifier No. 2. In the event that this is not possible or desirable, this overflow may be directed to Primary Clarifier No. 1 or to both primary clarifiers by manipulation of the valves in the lime effluent flow box. Lime mud thickener overflow piping is shown in schematic form on Figure 71.



NOTES:

1. FOR NORMAL OPERATION CLOSE SLIDE GATES ON TERTIARY SLUDGE LINE AND ON 10" LINE TO PRIMARY CLARIFIER NO. 1. OPEN SLIDE GATE TO PRIMARY CLARIFIER NO. 2. OPEN GATE VALVE ON TERTIARY SLUDGE LINE
2. SCREW PLUG PROVIDED IN LIME SPLITTER BOX TO CLOSE OFF LIME FEED TO ANY PRIMARY CLARIFIER NOT IN OPERATION.
3. LIME SOLUTION FEED HOSES FROM LIME SPLITTER BOX. SEE FIGURE 64 AND NOTE 2.

FIGURE 71

LIME FEED PIPING AND LIME MUD THICKENER OVERFLOW PIPING TO PRIMARY CLARIFIER NOS. 1 AND 2

Primary Sedimentation. Raw sewage, after passing through the screens or Barminutors and after being mixed with lime feed, enters either or both of the primary clarifiers. In the quiescent conditions prevalent in these clarifiers, suspended solids having a specific gravity greater than that of water settle to the clarifier bottom, and those lighter than water float to the clarifier surface.

Floating solids, called scum, are flushed to the influent end of Primary Clarifier No. 1 by means of solenoid valve operated automatic water sprays. Once concentrated near the influent end of Primary Clarifier No. 1, the scum is automatically removed from the liquid surface of the clarifier by means of a time clock controlled scum skimmer. This skimmer consists of a series of helical blades rotated by a motor which paddles the scum into a collection trough from where it flows by gravity to sump located at the north end of the equipment room. Primary Clarifier No. 2 is equipped with an automatic rotating skimming arm which sweeps the surface of the clarifier, pushing the accumulated scum up a ramp into a scum box. Scum flows by gravity from this box into a concrete scum pit located on the south wall of Primary Clarifier No. 2. The contents of both scum pits must be manually pumped at least once per shift or oftener if required. Sludge transfer pump No. 3 is normally used for this purpose; however, in the event that this pump is inoperative, any one of the three other sludge transfer pumps may be utilized to pump the scum. Figures 29 through 34 illustrate the operation of the transfer pumps and required settings for the various valves under several different methods of operation. After pumping, each scum pit should be thoroughly washed down, using the hose provided, to minimize grease accumulations in, and odor production within, the scum pits.

Solids which settle to the bottom of the primary clarifiers are called either raw or primary sludge. Primary sludge is collected by plows in the clarifiers and moved to sludge hoppers which are constructed as a part of the clarifiers. Once in the hoppers, the sludge is concentrated by the weight of liquid above the sludge hoppers.

Sludge Withdrawal. Under normal operation, sludge is pumped periodically from the two sludge hoppers by sludge transfer pump Nos. 1 and 2. These pumps are normally automatically controlled by means of adjustable time clocks. Proper adjustment of the length of pumping cycle will be dependent on the amount of raw sludge solids present in the sewage to be treated. Figure 72 shows the relationship between flows, suspended solids concentration in the raw sewage, and required raw sludge pumping rates at various sludge thicknesses. The use of Figure 72 as an aid to estimating required raw sludge pumping rates is explained by the following example:

1. Assume raw sewage flow is 4.0 mgd.

2. Assume lab tests show the suspended solids in the raw sewage to be 200 mg/l.

3. Assume it is desired to pump sludge having a solids concentration of 5 percent solids.

Procedure:

1. Using the top scale (total raw sewage flow; mgd), enter the chart at a point equal to 4.0 mgd. (Point A)

2. Draw a light line vertically down from Point A until it meets the sloping black line representing suspended solids = 200 mg/l. (Point B)

3. Draw a light line horizontally to the left until it meets the vertical scale (raw sludge solids produced; lbs. dry solids/day). (Point C). Read the lbs. solids produced = 4,300 lbs./day.

4. Draw a light line horizontally to the right until it meets the sloping red line representing sludge concentration = 5%. (Point F)

5. Draw a light line vertically down to the bottom scale (total raw sludge required to be pumped; gallons/hour) and read the value from the scale. Required pump rate = 425 gallons/hours.

Using the same given values in another example except changing the sludge concentration from 5 percent to 3 percent, it can be seen that the total raw sludge solids produced remains 4,300 lbs./day but that because of a thinner sludge being withdrawn, (3% - Point D), required pumping rate (Point E) would be nearly 725 gallons/hour. This example illustrates the tremendous advantages of pumping as thick a sludge as possible because all excess water must be evaporated in the sludge incineration furnace thus requiring much greater amounts of fuel.

The required sludge pumping rate shown on Figure 72 is a total amount. During normal operation (both primary clarifiers in operation) this total must be divided among the two pumps used. During normal operation, raw sewage flow is automatically divided to the two primary clarifiers in the ratio of about one-third to Primary Clarifier No. 1 and two-thirds to Primary Clarifier No. 2. Referring to Figure 29, it can thus be seen that sludge transfer pump No. 1 must pump two-thirds of the sludge and sludge transfer pump No. 2 must pump one-third of the sludge. Since one-third is half as great as two-thirds, it follows that under normal operation sludge transfer pump No. 1 should be operated twice as much as sludge transfer pump No. 2. Two means are provided for adjustment of pumping rates for sludge transfer pump Nos. 1 and 2. These are: (1) adjustable timers which permit adjustable pump cycles of from 0 to 60 minutes out of each hour; and (2) stroke adjustment of the positive displacement pumps which permits varying the pumping rate.

Sludge transfer pump Nos. 1 and 2 are furnished with constant speed motors and a fixed belt-driven sheave which is sized so as to operate the pumps at approximately 40 strokes per minute. Since the pump cylinder diameter is 10 inches, it can be computed that each pump will produce about 13 gallons of flow per minute for each one inch increment of stroke length.

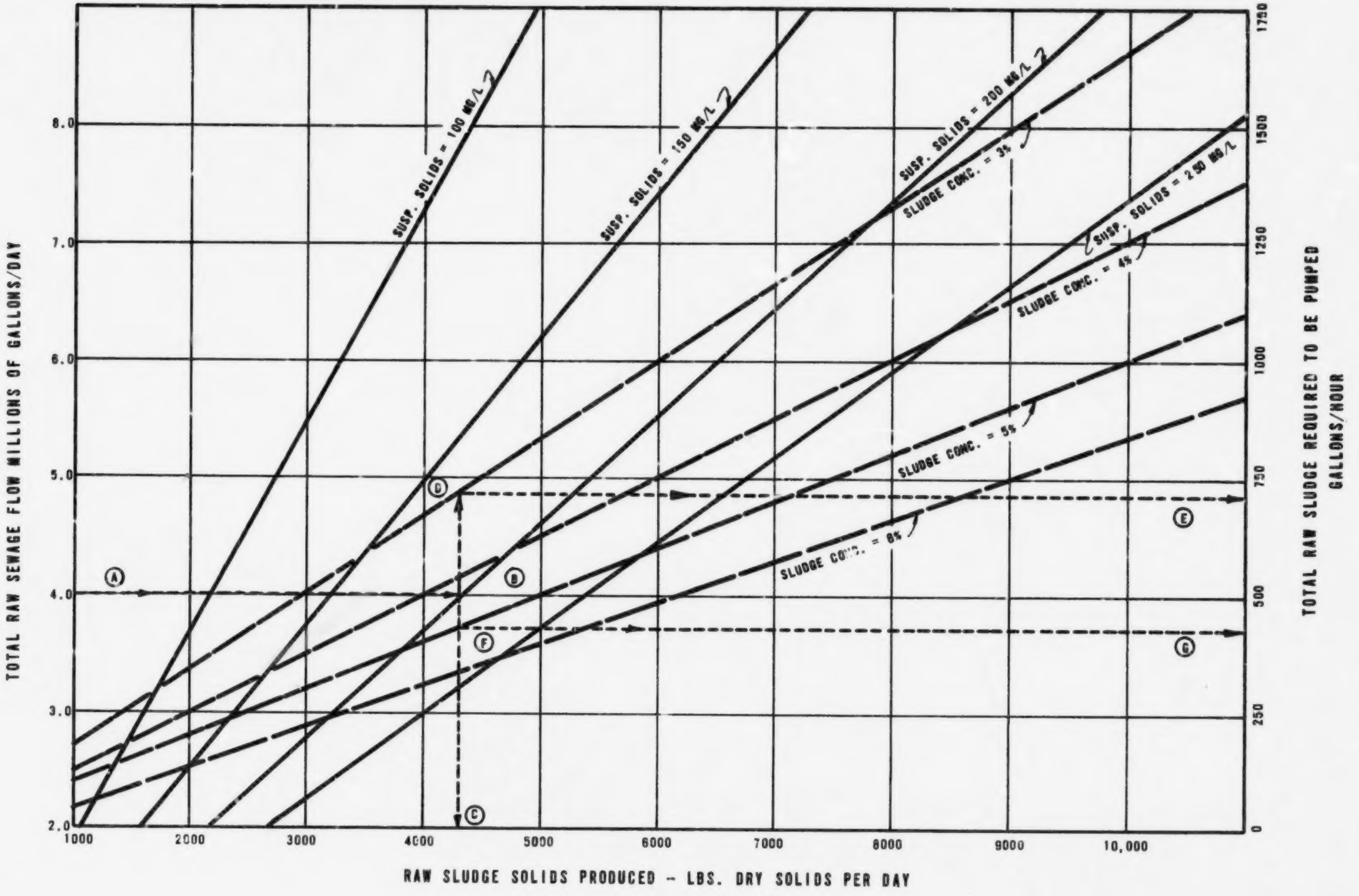


FIGURE 72

RAW SLUDGE PUMPING

Maximum stroke length is 6-3/4 inches. For normal operations, the stroke should be set at about 4 inches (refer to instructions supplied by pump manufacturer) for sludge transfer pump Nos. 1 and 2. This will result in a pumping rate of approximately 50 gallons per minute for each pump.

The two timers for sludge transfer pump Nos. 1 and 2 are located in the incineration building and are mounted in electrical panel No. 67CC. These two timers normally should be adjusted for a one-hour cycle with the sludge transfer pump Nos. 1 and 2 operating as follows:

Time 0 Minutes - Start Pump No. 1

Time (As Required) - Stop Pump No. 1

Time 30 Minutes - Start Pump No. 2

Time (As Required) - Stop Pump No. 2

In the event that one or the other of the two primary clarifiers is out of service, the sludge transfer pump serving that clarifier should be turned off and the timer of the remaining sludge transfer pump adjusted to provide a longer "On"-cycle as required. Consult the information supplied by the timer manufacturer before attempting to change the timer settings.

Using as an example the same flow and suspended solids as previously discussed, the following sample calculations indicate the method of computing the required timer settings:

Given Information.

1. Sewage flow = 4.0 mgd (from flowmeters)
2. Suspended Solids Conc. = 200 mg/l (from lab test)
3. Primary Clarifiers 1 and 2 in operation
4. Sludge conc. desired = 5%
5. Pump stroke setting = 4 inches

Procedure:

1. Using Figure 72 determine the required pumping rate = 425 gallons/hour.
2. With a 4-inch stroke, pump rate = 50 gpm
3. $\frac{\text{Required flow/hour}}{\text{Pump rate/min.}}$ = Total pump time in minutes/hour

$$\frac{425}{50} = 8.5 \text{ minutes per hour}$$

4. Proportion total time - 2/3 for sludge transfer pump No. 1
   1/3 for sludge transfer pump No. 2

$$\frac{8.5}{3} = 2.8 \text{ minutes} \quad 2 \text{ min. } 48 \text{ secs. (Pump No. 2)}$$

$$8.5-1.8 = 5.7 \text{ minutes} = 5 \text{ min. } 42 \text{ secs. (Pump No. 1)}$$

5. Set timers as follows:

Set Timer No. 1	on period	5 min. 42 sec.
	off period	54 min. 18 sec.
	pointer at	0 min.
Set Timer No. 2	on period	2 min. 48 sec.
	off period	57 min. 12 sec.
	pointer at	30 min.

It is important that the two timers always be set in such a manner that both sludge transfer pumps do not operate simultaneously because this could possibly result in overflowing of the sludge thickener day tank.

When scum is pumped to the thickener day tank, it is recommended that pumping be done during times when raw sludge is not being pumped since this practice will minimize fluctuations in total load to the incineration system.

Secondary Treatment (Biological Treatment).

General. The objective of secondary treatment at the South Tahoe P.U.D. Water Reclamation Plant is to remove nonsettleable suspended organic solids and dissolved organic material by biological means. This plant employs the activated sludge system to achieve the above stated objective.

In simple terms the activated sludge system consists of a biological reactor (aeration basins) in which waste is contacted with an active mass consisting primarily of bacteria (activated sludge), followed by settling basins (secondary clarifiers) in which the active mass is removed by sedimentation and returned to the biological reactor. The clarified effluent is then subjected to tertiary treatment processes as described in following sections of this manual.

Aeration Basins. Two distinct types of aeration basins are provided. The older, original system employs long narrow basins in which flow enters at one end, passes down the length of the basin and exits at the opposite end. These basins (Nos. 1, 2, and 3) are termed plug flow basins. The new addition employs basins in which flow enters uniformly throughout the basin's length and exits uniformly throughout the basin length. These basins (Nos. 4 and 5) are termed complete mix basins.

Diffused Air Aeration. Oxygen and mixing required for operation are provided in the case of the plug flow basins by admitting compressed air through devices called spargers located near the bottom and at one side of the plug flow basins. The compressed air forms bubbles upon release in the liquid and the rising of these bubbles causes a rolling action, thus mixing the tank contents. Oxygen contained in the air bubble passes into the liquid in the basin. Although the total amount of oxygen required in these basins is relatively small, large quantities of air are required since the efficiency of transfer of oxygen with this system is rather low.

Mechanical Aeration. Oxygen and mixing required for operation are provided in the case of the complete mix basins by means of a combination of mechanical mixers and compressed air. Compressed air is admitted near the bottom of the complete mix basins directly underneath the mechanical mixers from large pipes. Very large bubbles of air rise under the mixers and are sheared by the rotating mixers into much finer air bubbles. The required mixing is for the most part achieved by mechanical means; i.e., by the rotating action of the paddle wheels. Overall oxygen transfer efficiency is much greater with this system; however, the energy requirements of the motor driven mechanical mixers offset to a large degree, the savings realized because of smaller air compressor (blower) requirements.

Return Activated Sludge (RAS). In order to operate any activated sludge system properly, assuming that required oxygen and mixing are provided, it is only necessary to provide a source of complete food (sewage) and population of organisms (activated sludge) to "eat" the food. By thinking for a moment about this statement the following inferences may be drawn:

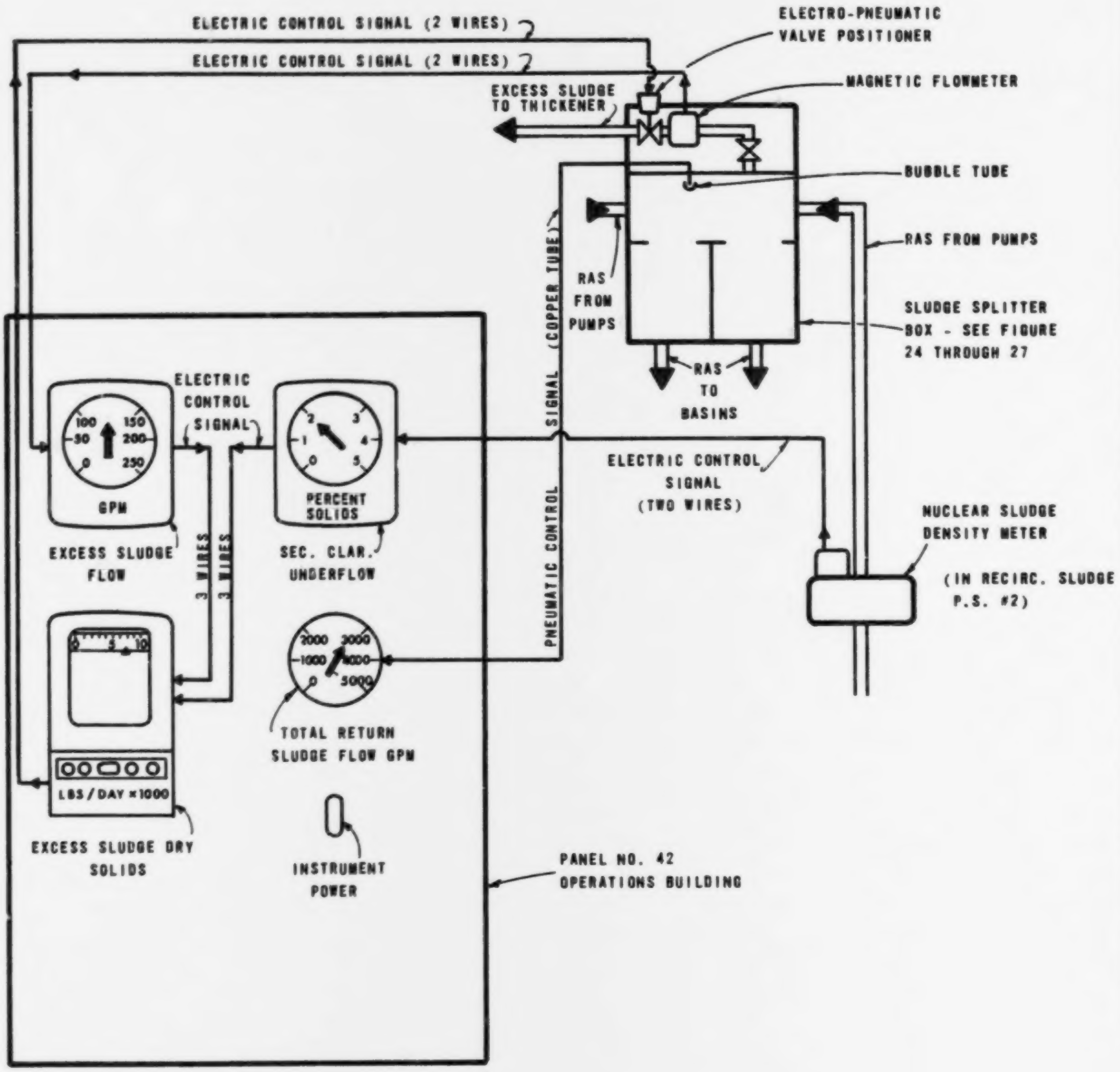

ELECTRIC CONTROL SIGNAL (2 WIRES)
ELECTRIC CONTROL SIGNAL (2 WIRES)
ELECTRO-PNEUMATIC VALVE POSITIONER
EXCESS SLUDGE TO THICKENER
MAGNETIC FLOWMETER
BUBBLE TUBE
RAS FROM PUMPS
RAS FROM PUMPS
SLUDGE SPLITTER BOX - SEE FIGURE 24 THROUGH 27
RAS TO BASINS
PNEUMATIC CONTROL SIGNAL (COPPER TUBE)
ELECTRIC CONTROL SIGNAL
GPM
100 150 50 200 0 250
EXCESS SLUDGE FLOW
PERCENT SOLIDS
2 3 1 4 0 5
SEC. CLAR. UNDERFLOW
3 WIRES
3 WIRES
ELECTRIC CONTROL SIGNAL (TWO WIRES)
NUCLEAR SLUDGE DENSITY METER
(IN RECIRC. SLUDGE P.S. #2)
0 5 10
LBS/DAY ×1000
EXCESS SLUDGE DRY SOLIDS
2000 3000 1000 4000 0 5000
TOTAL RETURN SLUDGE FLOW GPM
INSTRUMENT POWER
PANEL NO. 42 OPERATIONS BUILDING

FIGURE 73

SLUDGE WASTING CONTROL SYSTEM

1. If available food exceeds the feeding capacity of the available organisms, a portion of the food will pass through the system unused. This would result in low BOD removal percentages.

2. If available food is significantly less than the requirements of the organisms, natural competition for the food supply will result in eventual death of a portion of the organisms. This results in a high BOD removal percentage but severely limits the ability of the entire system to properly treat shock loads.

3. The concentration of available active organisms always tends to adjust itself to the available food supply. This adjustment is accomplished either by death of existing, or growth of new, organisms.

In order to affect separation of the biological organisms responsible for secondary treatment from the liquid fraction of aeration basin effluent, it is necessary to have activated sludge which is readily settleable. Activated sludge which is actively growing (abundant food supply) will not properly settle because the individual organisms have surplus energy and do not clamp together to form large heavy "floc" particles. Conversely, activated sludge organisms not in active growth (scarce food supply) clump together and settle rapidly, thus providing good separation from the liquid fraction of the waste.

The relationship between available food (sewage) and the activated sludge organisms which is required for good operation of any activated sludge treatment system, can be controlled by either varying the food supply or the total amount of activated sludge organisms. Since the plant operator cannot vary the sewage flow under normal circumstances, he must instead vary the concentration of organisms. Variations in the concentration of organisms are accomplished by changing the total weight (dry basis) of activated sludge which is recirculated to the aeration basins (return activated sludge or RAS) in order to maintain the mixed liquor suspended solids (MLSS) concentration in the aeration basin within certain acceptable limits. These acceptable limits are discussed in detail in a later section of this manual.

Waste Activated Sludge. Activated sludge systems produce an excess of biological solids over amount required for operation. These solids must be removed from the system to avoid the build-up of abnormally high mixed liquor suspended solids concentrations. Solids thus removed are termed Waste Activated Sludge or Excess Sludge.

The system employed for sludge wasting is semi-automatic and is intended to waste sludge at a variable rate on a *continuous* basis. The wasting of sludge must *never* be done on a periodic basis as this will inevitably lead to process upsets and possible overloading of sludge handling and incineration equipment. If required to maintain desirable MLSS concentrations, sludge wasting may be discontinued for as long as necessary; however, when wasting is resumed, continuous operation must prevail.

Figure 73 illustrates the various equipment components which make up the Waste Activated Sludge Control System.

Briefly the operation of the waste activated sludge control system is as follows:

1. The portion of total Return Activated Sludge (RAS) pumped by the new sludge recirculation pump station passes through a nuclear density gauge. This device determines the density of the RAS, and, by comparing this density to that of water, produces a millivolt direct current electric signal.

2. This signal is amplified and then sent to an instrument located in panel 42 in the operations building. This instrument compares the signal to a fixed value, indicates the strength of the signal on a scale calibrated in percent solids, and retransmits the signal to a second instrument called a mass density recording indicating controller.

3. Excess activated sludge which is being wasted flows through a magnetic flowmeter located in the sludge splitter box dry pit. This meter generates a millivolt direct current signal proportional to the rate at which sludge is wasted. This signal is amplified and sent to an instrument located in panel 42 in the operations building. This instrument compares the signal to a fixed value, indicates the strength of the signal on a scale graduated in gallons per minute, and retransmits the signal to the mass density recording indicating controller.

4. The mass density recording indicating controller multiplies electrically the two millivolt signals transmitted to it, records and indicates the product on a scale calibrated in pounds of dry solids wasted per day, compares the value with a value set into the instrument by the operator, and transmits a correction signal as required to the butterfly valve which controls the rate at which sludge is wasted. This correction signal activates the valve positioner, opening the valve if the actual sludge wasting rate is less than the set amount and closing the valve if the rate is in excess of the set amount.

5. A bubble tube located in the sludge splitter box generates a pneumatic signal proportional to head on the sludge splitting weirs. This 3-15 psi pneumatic signal is transmitted to an instrument located in panel 42 in the operations building, which indicates total return sludge pumping rate on a scale calibrated in gallons per minute.

Excess or waste activated sludge which is produced flows by gravity from the sludge splitter box to the waste activated sludge thickener for additional processing prior to disposal by incineration. In the event that the thickener is out of service, sludge can be wasted by manipulation of the valves adjacent to sludge recirculation pump station No. 2 as shown on Figure 23.

Chemical Treatment & Phosphate Removal.

General. The purposes of chemical treatment are (1) clarification, (2) preparation for ammonia stripping and filtration, and (3) phosphate removal. In order to get phosphates out of the treatment system, chemical treatment is carried out in two stages. The first stage is chemical application to the primary influent, and the second stage is accomplished in the chemical treatment units consisting of flash mix, flocculator, and chemical clarifier. The routing of flow through the chemical treatment portion of the plant is shown on Figures 7 through 12. Water flowing through the chemical treatment units is principally secondary clarifier effluent, but also may contain some flow from the backwash water decanting tank (see Figures 52 and 53) which may consist either of only the settled calcium carbonate sludge (Figure 52), or all of the unsettled backwash water (Figure 53).

Chemicals. The main coagulant and phosphate adsorbent is lime. Alum and polyelectrolyte may be used as coagulant aids. Alum also will adsorb phosphates. Part of the lime used in treatment will be fresh commercial makeup lime, and the rest will be recalcined lime recalcined from chemical clarifier sludge.

Certain minimum dosages of lime are required for clarification of the waste water, and some phosphate removal is secured incidental to this process. However, additional quantities of lime are required in order to obtain the desired phosphate reductions and to raise the pH as required for ammonia stripping. A lime dose of 100 mg/l will raise the pH to about 9.3 and remove about 60 percent of the phosphates present in raw sewage, and an additional 300 mg/l of lime will raise the pH to 11.5+ and remove another 35 percent of the phosphates. By splitting the total lime dose in this proportion between the primary influent and flash mix, most of the phosphates will be precipitated in the primary clarifiers, and thus will be removed from the treatment system when incinerated along with the primary sludge. Ordinarily, all lime fed to the primary influent will be recalcined lime. Since the recalcined lime contains some phosphates, they also will be removed from the system in the primary sludge. Usually all of the fresh makeup lime will be fed to the rapid mix together with enough recalcined lime to make up the total lime dose. The phosphates adsorbed by this lime are settled out in the chemical clarifier sludge and are recirculated back to the treatment system in a portion of the recalcined lime. The fresh commercial makeup lime will contain about 88 percent CaO. The recalcined lime will contain from 75 to 85 percent CaO, averaging about 80 percent CaO. Addition of lime to the waste water raises the pH of the water. Ordinarily enough recalcined lime (about 100 mg/l) will be added to the primary influent to maintain a pH of 9.3 in the primary effluent water. Enough makeup (about 100 mg/l) and recalcined (about 200 mg/l) lime will be added to the flash mix to maintain a pH of about 10.8+ in the chemical clarifier effluent.

For the Tahoe raw sewage, lime alone is a good coagulant. However, in the expanded plant the primary clarifiers will also be receiving a quantity of extremely finely divided solids in the centrate from the sludge and lime centrifuges. If these fines are not adequately removed by use of lime alone, it may be necessary to feed alum or a polyelectrolyte or both to the primary influent, or to the flash mix basin. The proper dosage of alum or polyelectrolyte needed to improve clarification will have to be determined by the results of full-scale plant operation. It is expected that the alum dose, if required, would be 20 mg/l or less, and the polyelectrolyte dose, if required, would be from 0.1 to 1.0 mg/l.

Rapid Mix. A mechanical rapid mix (or flash mix) of about one minute's duration is provided for mixing lime and other treatment chemicals with the secondary effluent. The purpose of the rapid mixer is to secure complete and uniform dispersion of the treatment chemicals in all of the water.

Flocculation. The purpose of flocculation (slow mix) is to bring the coagulated particulate matter, phosphates, and treatment chemicals into repeated contact, so that the particles of floc formed will stick together and grow to a size and density which will permit their separation from the water by settling. Only about five minutes of air-mixing is required to flocculate the chemically treated Tahoe secondary effluent.

Chemical Clarifier. The purpose of the chemical clarifier is to provide a quiescent period during which the floc particles can settle out of the water by gravity to the bottom of the tank. The clarifier is equipped with continuous sludge collection equipment. The chemical clarifier captures any solids which may carry over or spill from the secondary clarifiers as a result of upsets in biological treatment. At maximum design loading the surface overflow rate in the chemical clarifier is 950 gallons per square foot per day. The chemical clarifier greatly reduces the load of solids reaching the separation beds or filters, the effluent turbidity being 10 J.U. or less.

Lime sludge will be withdrawn continuously through the suction pipes of the RSR clarifier mechanism. The amount of sludge withdrawn from the basin should be sufficient to avoid overloading the collection arms and to prevent floc carry-over from the basin. Excessive withdrawals would result in a thin sludge (say less than one percent solids). The rate of sludge withdrawal through the suction pipe will be in the range of 150 to 400 gpm depending on plant flow. Lime sludge will also be withdrawn periodically (for about 10 minutes once per shift) by manual pumping from the center sludge pocket which receives sludge from the bottom scrapers.

Recarbonation (Alternate). Provisions are made for recarbonation (introduction of compressed carbon dioxide gas) of the chemical clarifier effluent in the outer collection launder. Until construction is completed of the ammonia stripping tower and the two-stage recarbonation facilities, this will be the only means of recarbonation. Following completion of the ammonia stripping tower, the two-stage recarbonation treatment will be used normally, and recarbonation in the chemical clarifier effluent launder will become a standby method for use only when the stripping tower and two-stage recarbonation facilities are both out of service. The pH of the clarifier effluent will be about 10.8+. With the initial installation this will be reduced to pH 8.5 to 9.0 in a single step, and there will be considerable carry-over of calcium carbonate floc to be removed by the separation beds.

Nitrogen Removal.

Ammonia Stripping. In this plant, nitrogen removal is accomplished by ammonia stripping at pH 10.8+. As described previously, the biological treatment section of the plant is operated to maintain the incoming nitrogen in ammonia form by keeping a BOD/VSS ratio above 0.35. The pH is raised by lime to 10.8+ and the primary clarifier effluent is pumped to the top of the ammonia stripping tower. Water passes down through the tower over a series of splash bars where ammonia is removed during droplet formation. Air is circulated laterally through the tower by large fans. When the tower is operating at less than design capacity, ammonia removal efficiency can be increased by recirculation of tower effluent. Some of the factors which influence the efficiency of ammonia removal in the tower are:

1. pH
2. Hydraulic loading
3. Number of droplet formations
    a. Spacing of packing
    b. Height of tower
    c. Water recirculation
4. Water temperature
5. Amount of circulating air

Part of these factors are subject to operator control; others are not.

For maximum ammonia removal the tower influent pH should be at least 10.8. The pH can be increased as desired by increasing the lime dose.

Decreased hydraulic loadings will increase tower efficiency, and recirculation of tower effluent increases tower efficiency. Obviously, these two factors are working in opposite directions; that is, increased recirculation tends to increase efficiency by providing more droplet formations but also produces a greater hydraulic loading on the tower which reduces tower efficiency. For maximum ammonia removal, a proper balance must be obtained. From an operational standpoint there is not a great deal of selection to be made in this regard. The pumpage to the tower will always slightly exceed plant throughput, so that some tower effluent is always being recirculated. When plant flow exceeds the capacity of one tower pump, the second pump must be used.

Increased water temperatures also increase ammonia removals, but this cannot be controlled.

Increased air circulation also increases ammonia removal. The fans should be operated at maximum capacity except when air circulation must be restricted to prevent freezing.

Primary Recarbonation. Beneath the ammonia stripping tower, there is a primary recarbonation basin, a reaction basin, and a secondary recarbonation basin. In the first stage of recarbonation, the pH of the tower effluent is reduced to 9.3 which is near the pH of minimum calcium carbonate solubility.

Reaction Basin. Formation of calcium carbonate at pH 9.3 is not instantaneous, several minutes being required at normal water temperatures for complete reaction. The main purpose of the reaction basin is to provide this reaction time, and to thus obtain the maximum calcium recovery. However, some of the calcium carbonate particles formed will flocculate and settle to the bottom of the reaction basin. Mechanical sludge collection equipment is provided to collect the settled lime sludge, which is returned through the lime mud thickener to the lime recalcining plant. Sludge withdrawal at a uniform rate of about 50 gpm probably will give the best operation of the lime recalcining equipment.

Secondary Recarbonation. The second stage of recarbonation is provided to stabilize the water with respect to calcium deposition. The pH is reduced from 9.3 to a final pH in the range of 8.5 to 9.0.

Filtration.

Chemicals. It is possible to add alum to the combined filter influent and to feed polyelectrolyte to each individual separation bed. Alum is applied only if necessary to obtain the desired turbidity in the finished water. Polyelectrolyte (or secondary flocculant) is added as a filter aid to control floc breakthrough.

Separation Beds. There are three pairs of separation beds. Each pair of beds operates in series, and the three pairs operate in parallel. At 5 gpm per square foot, the 3 pairs of beds will handle 5,700 gpm (8.1 mgd). With an allowance of 10 percent downtime for backwashing, the firm net output is 7.5 mgd. The depth of media in each bed is 3 feet. The filter media is a special patented (Neptune MicroFLOC, Inc.) coarse-to-fine media. The separation beds remove all of the remaining particulate matter from the waste water producing an effluent with a turbidity of 0.1 to 0.5 J.U. (Jackson Units). The high clarity of this water as applied to the granular activated carbon avoids carbon column plugging and increases carbon adsorption efficiency.

Backwashing. When the head loss through the filters reaches a predetermined maximum (say 20 feet), or effluent turbidity exceeds 0.5 J.U., then each pair of beds is taken off the line (one pair at a time in sequence) backwashed, and returned to service. The beds are backwashed with chemical clarifier effluent water by means of a backwash pump and a surface wash pump. Each bed is backwashed at a rate of 5,700 gpm (15 gpm per square foot of separation bed surface area). The backwash water enters the bottom of the second bed, passes upward through it, then through a 16-inch strainer, and then upward through the first bed. The wash water is discharged to a decanting tank. The separation beds are equipped with rotary surface washers or agitators. The duration of backwash is about 10 minutes.

Decanting Tank. The backwash water decanting tank may be used in one of two ways: (1) as a storage reservoir to equalize the rate-of-flow at which wash water is returned to the process, or (2) as a means of separating solids and liquid for return to different points in the process. (See Figures 52 through 55).

Carbon Adsorption. There are eight columns of granular activated carbon which are operated upflow in parallel. The carbon adsorbs ABS, COD, color, odor, and other organic materials from the waste water. Since the carbon columns are upflow, spent carbon is withdrawn from the bottom of the columns and fresh carbon is added at the top. This is a complete countercurrent flow pattern with all of the efficiency advantages inherent in this type of operation. At this time, the presence of more than 25 mg/l of COD in the effluent from a carbon column is taken as the signal that carbon regeneration is needed. Color breakthrough follows very closely the COD breakthrough.

Disinfection. Chlorine may be added to the raw sewage for odor control or to aid in preventing bulking of activated sludge. Chlorine may also be added to the separation bed influent to aid in controlling possible slime growths in the beds, if necessary (none have been observed to date). The main point of chlorination is in the final effluent pump sump for purposes of disinfection.

Granular Activated Carbon Regeneration. The plant includes a complete carbon regeneration system for transferring spent carbon from the carbon columns, storing and dewatering the spent carbon, feeding it at a controlled rate to the furnace, thermally regenerating the carbon, quenching the carbon, pumping the regenerated carbon to storage tanks, adding new makeup carbon by pumping from the slurry bin, storing the regenerated and makeup carbon, conveying the regenerated carbon to the carbon columns, and disposing of the furnace exhaust gases without nuisance from dust, smoke, or odor.

Spent carbon is withdrawn from the bottom (water inlet end) of the carbon columns for regeneration, and regenerated and new makeup carbon are added at the top (water outlet end) of the column. This is the so-called "countercurrent" method of column operation which brings the most polluted water into contact with the most nearly saturated carbon, thus increasing adsorption, and which brings the freshest carbon into contact with the partially purified water which favors adsorption of the last traces of impurities.

Carbon withdrawn from the columns for regeneration is discharged into dewatering tanks for the spent carbon. These tanks are located just below roof level in the building.

Each dewatering tank will hold a slug of about 155 cubic feet (4,650 pounds dry weight) of carbon, or a total of 310 cubic feet (9,300 pounds dry weight) in the two tanks. This is based on leaving a one-foot deep "heel" of carbon above the screw conveyor in the bottom of the tank, and on a 45-degree slope of the top of the carbon from the inlet pipe on one side of the tank. One slug will draw the carbon level down 7 feet, which is below the level of the bottom of the outlet screens and is about one foot down the straight wall of the column. Two slugs will draw the carbon level down near the bottom of the column manhole, and 11 slugs are necessary to empty a column or to completely renew its contents.

When a slug of carbon is deposited in the spent carbon bin, it must be dewatered to 50 to 60 percent moisture before it can be fed to the carbon regeneration furnace. This usually takes about 15 minutes.

The screw conveyors serve two purposes; they convey the dewatered carbon to the furnace and they feed it at a controlled rate which is necessary for proper regeneration.

The furnace is designed to operate at rates of 1,000 to 6,000 pounds per day of carbon (dry basis). This corresponds to 33.3 to 200 cubic feet per day, or 0.023 to 0.138 cubic feet per minute. The 9-inch screw has a 9-inch pitch, and at 100 percent efficiency (no slippage) theoretically delivers 0.25 cubic feet per revolution, and the 3-inch pitch section 0.083 cubic feet per rev. At 100 percent efficiency, the screw speed for the 3-inch pitch section should be 0.3 to 1.8 rpm. The screw is driven through a Winsmith Reducer (952.6 to 1 reduction) by a Reeves Drive which can be varied from 216 to 2,160 rpm. After reduction, the speed range for the drive is 0.2 to 2.0 rpm. To deliver 6,000 pounds per day then, the 9-inch portion of the screw must have an efficiency of at least 30 percent, and the 3-inch pitch section an efficiency of 90 percent (10 percent slippage).

In the furnace the carbon is thermally regenerated at a temperature of 1,750 degrees F. in the presence of steam. The heat vaporizes and drives off as gas the impurities which are adsorbed on the carbon, and the regenerated carbon is returned to virgin activity. Operation of the furnace is controlled routinely by the apparent density of the carbon, supplemented at times by tests of iodine number, adsorption isotherms, or other laboratory tests to check the activity of the regenerated carbon.

The furnace is equipped with an afterburner to eliminate odors if necessary and a wet scrubber to eliminate dust from the exhaust stack gas.

The carbon is discharged from the furnace by gravity into a quench tank, where the carbon is cooled and put into water slurry. The carbon slurry is pumped by either of two air-operated Oliver Diaphragm slurry pumps having a rated capacity of 3 to 20 gpm each. The pumps take suction from the quench tank and discharge into the regenerated carbon storage tanks.

Each of the two regenerated carbon storage tanks will hold about 140 cubic feet (4,200 pounds, dry weight) of carbon, or a total of 280 cubic feet (8,400 pounds) in the two tanks. The regenerated carbon storage tanks are equipped for fines removal from the carbon. A flow of water can be directed upward through the tank through a screen at the top. The fines are wasted to the ballast ponds with the wash water, and the de-fined carbon remains in the tank. Carbon is transferred from the regenerated carbon storage tanks to the top of the carbon columns by pressurizing the storage tanks with water. There is a pressure water connection in the carbon discharge line just below the storage tanks. Water flow should be established by means of this connection before the carbon is released into the line, and the water flow should not be stopped until the storage tank and pipeline have been flushed free of the carbon.

There will be about a 5 percent loss of carbon during each regeneration cycle. This loss will have to be made up with new carbon at the rate of about four 60-pound bags for each slug drawn to a spent carbon dewatering tank.

The bags of makeup carbon can be dumped into the carbon slurry bin through opening above the bin which is equipped with a dust collector. From the slurry bin, the carbon slurry is pumped by an Oliver Diaphragm pump having a capacity of 12 to 50 gpm to the regenerated carbon storage tanks, where it can be de-fined and then forced under pressure to the top of the carbon columns as for the regenerated carbon.

Sludge Incineration.

Waste Activated Sludge Thickening. Prior to incineration, waste activated sludge is normally thickened to reduce the amount of water which must ultimately be evaporated during the incineration process. Figure 36 shows the thickening equipment provided. Waste activated sludge fed to the thickener is controlled by the waste sludge control system previously described. Polyelectrolyte in the amount of from 2 to 16 pounds per ton of dry solids fed will normally be added prior to feeding the conditioned waste sludge fed to the thickener. Exact types and amounts of polyelectrolyte to be added can only be determined by experimentation. The thickener equipment manufacturer will conduct tests and make recommendations concerning this. Polyelectrolyte will be mixed and stand in liquid form in the mixing tank provided. The capacity of this tank is 350 gallons. The tank is equipped with mixer, water meter and variable speed feed pump. The following procedure is recommended for mixing the polyelectrolyte solution:

1. Weigh or measure volumetrically the amount of pure polyelectrolyte to be used.

2. Determine amount of mixing water to be used.

3. Reset water meter to 0.

4. Turn on propeller mixer.

5. Turn on mixing water supply valve.

6. Pour measured amount of polyelectrolyte through eductor funnel while mixing water is flowing.

7. Shut off mixing water when water meter registers correct volume of mixing water.

8. Allow propeller mixer to run 30 minutes, then shut off.

Figure 74 shows graphical methods of determining proper polyelectrolyte feed pump settings. Graph A is used to determine total polyelectrolyte feed requirements in lbs/day at various feed rates. Graph B is then used to determine the required feed rate in gallons of polyelectrolyte mixture.

Finally, Graph C is used to determine correct polyelectrolyte pump speed in rpm. As an example assume the following conditions:

1. Sludge wasting rate = 7,000 lbs dry solids/day (obtain from mass density recording indicating controller).

2. Required polyelectrolyte feed = 6 lbs per ton dry solids (obtain from manufacturers recommendations and lab tests).

3. Polyelectrolyte mixture = 1 percent.

4. Pump stroke = 1-1/2 inches.

5. Using the 6 lbs/ton curve on Graph A read required polyelectrolyte on vertical axis = 21 lbs/day.

6. Using the 1 percent curve on Graph B read required polyelectrolyte feed rate on the vertical axis = 10 gph.

7. Using the 1-1/2-inch stroke curve on Graph C read required pump speed on the vertical axis = 300 rpm.

The polyelectrolyte mix tank is 4'-0" diameter x 4'-3" depth. It, therefore, has a volume equivalent to 7.85 gallons per inch of depth. Approximately 6 inches freeboard should be reserved for mixing purposes to eliminate splashing. The following table may be used to assist in the preparation of stock polyelectrolyte solutions.

Vol. of Solution to be Prepared	Total Available Tank Depth Req'd. (Includes 6-Inch Freeboard)	Pounds Polyelectrolyte to be Added to Tank to Make up Solution Strength as Noted				
		0.5%	0.75%	1.0%	1.5%	2.0%
50 gals	13 inches	2.1 #	3.15 #	4.2 #	6.3 #	8.4 #
100	19	4.2	6.30	8.4	12.6	16.8
150	25	6.3	9.45	12.6	18.9	25.2
200	32	8.4	12.60	16.8	25.2	33.6
250	38	10.5	15.75	21.0	31.5	42.0
300	44	12.6	18.90	25.2	37.8	50.4
350	51	14.7	22.05	29.4	44.1	58.8

Stock polyelectrolyte feed solutions should be made up in such volumes that they will be used within approximately 24 hours as a maximum. It is preferable to mix solutions as dilute as possible in order to obtain most accurate feed rates. Very viscous feed solutions tend to interfere with the ball check valves provided as a part of the feed pump. During periods of maximum solids loading of the sludge thickener, it may be necessary to mix polyelectrolyte solution as often as once per shift.

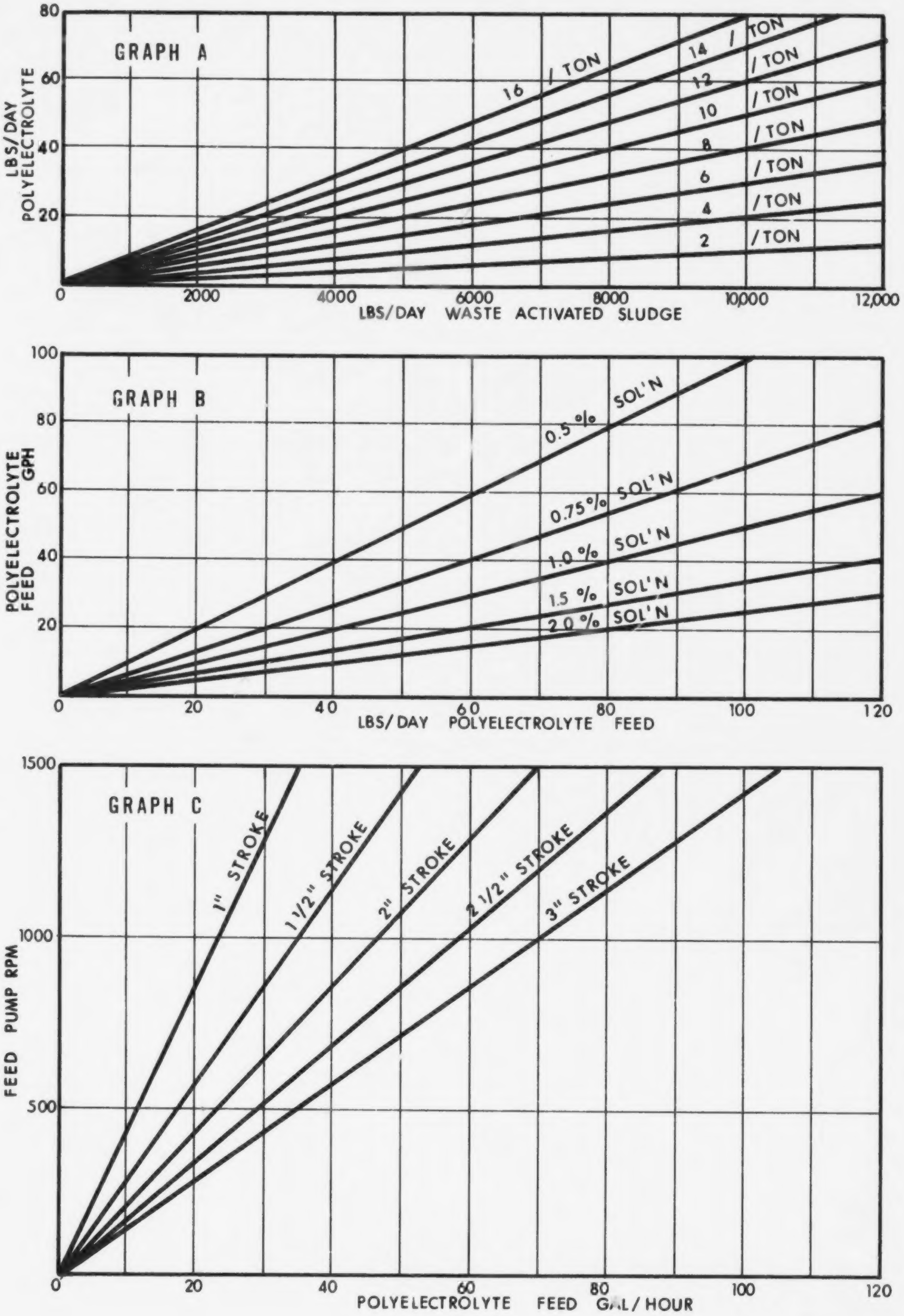

GRAPH A
LBS/DAY POLYELECTROLYTE
80
60
40
20
0
2000
4000
6000
8000
10,000
12,000
LBS/DAY WASTE ACTIVATED SLUDGE
16 / TON
14 / TON
12 / TON
10 / TON
8 / TON
6 / TON
4 / TON
2 / TON
GRAPH B
POLYELECTROLYTE FEED GPH
100
80
60
40
20
0
20
40
60
80
100
120
LBS/DAY POLYELECTROLYTE FEED
0.5 % SOL'N
0.75% SOL'N
1.0 % SOL'N
1.5 % SOL'N
2.0 % SOL'N
GRAPH C
FEED PUMP RPM
1500
1000
500
0
20
40
60
80
100
120
POLYELECTROLYTE FEED GAL/HOUR
1" STROKE
1 1/2" STROKE
2" STROKE
2 1/2" STROKE
3" STROKE

FIGURE 74

The sludge thickening process used operates by flotation of activated sludge particles using air bubbles as a flotation medium. The general process is as follows: A recirculation pump takes suction from either primary clarifier effluent or sludge thickener effluent (normally sludge thickener effluent) and pumps this flow (approximately 450 gpm) to a steel retention tank under approximately 70 psi pressure. Flow rate is adjustable by valve throttling and is measured by means of an orifice plate and manometer calibrated in gpm. Compressed air from the plant air system is admitted under pressure into the recirculation pump discharge line. The volume of compressed air is measured by a rotameter. Compressed air and water are retained in the retention tank and a second pump, called the recycle pump, pumps a flow of approximately 200 gpm from the retention tank and discharges this flow back to the retention tank. This recycling action acts to saturate the pressurized water within the retention tank with air. A flow of approximately 450 gpm is then bled from the retention tank and introduced into the thickener below the water surface as shown on Figure 36. Simultaneously, a flow of waste activated sludge, having had polyelectrolyte injected into itself, is introduced into the thickener. The flow of pressurized water upon introduction into the thickener immediately suffers an abrupt pressure drop of from approximately 70 psi to less than 5 psi. This causes the pressurized water flow to instantly become supersaturated with air and as a consequence, large volumes of air are released in the form of tiny bubbles. These bubbles mix with and attach themselves to sludge particles, concentrating the sludge as a thick surface layer called float. The float is then skimmed over a discharge ramp into a holding tank called the day tank. The skimming mechanism is driven by a small gearmotor mounted above the thickener. A set of bottom sludge collection flights similar to those in Primary Clarifier No. 1 and a screw cross collector are provided to collect and discharge sludge or grit particles which are too heavy to be floated. The drive end of the screw conveyor is fitted with a suction pipe which is interconnected with the sludge transfer pumps as shown on Figures 29 through 35. Periodically (once per shift should be sufficient) this screw conveyor should be pumped by opening its valve and closing the valve on the suction line from the day tank. About two minutes pumping should be sufficient to keep the screw cleared of bottom sludge accumulations. Care should be taken not to over-pump since this would result in discharge of unnecessary volumes of water to the sludge dewatering centrifuges.

As previously discribed, raw sludge from Primary Clarifier Nos. 1 and 2 as well as thickened waste activated sludge are normally discharged to the day tank. By proper manipulation of valves in the digester control house, it is also possible to bleed sludge from either digester back to the day tank. The day tank has a usable volume of approximately 7,000 gallons as measured below the emergency overflow. Maximum allowable depth in the day tank before emergency overflow occurs is 10'-8". Below a depth of 6 feet the day tank dimensions are such that it has a capacity of approximately 850 gallons per foot of depth. The purpose of the day tank is to mix thickened waste activated sludge with primary sludge or digested sludge and to provide a small storage volume, thus enabling the operator to pump mixed sludge to the incineration system at a uniform rate even though primary sludge is discharged to the day tank on a cyclical basis. Mixing is achieved by the use of air diffusers located in the bottom of the day tank on removable headers. Three such headers are provided and each is equipped with a throttling valve. The valves should be adjusted so as to admit as little air as possible and yet maintain adequate mixing. A bubble tube system is provided which measures depth of sludge in the day tank and indicates depth on gauges located in the operations building and in the incineration building control room. High and low level alarms are provided and may be individually adjusted to sound an alarm at the incineration building annunciator panel as well as in the operations building. Suggested settings are as follows:

Low Level Alarm 2'-0"

High Level Alarm 7'-0"

Since sludge is to be pumped to the day tank at varying rates on a cyclical basis and pumped from the day tank on a continuous basis, some depth fluctuation is to be expected. At maximum operating rates, depth fluctuations of approximately one foot above or below the desired average operating depth will occur if on an hourly basis, inflow is equal to outflow. It is suggested that an average depth of 4 feet be used as an operating depth. This would mean that depths of from 3 to 5 feet would be normal. Depths progressively decreasing or increasing above these would then indicate pump rates from the day tank are too great or small respectively.

Primary and Waste Activated Sludge Dewatering. Mixed sludge to be dewatered is pumped from the day tank to the sludge centrifuges by either sludge transfer pump No. 3 or No. 4. Normally No. 4 is used as shown on Figure 29. In the event that No. 4 is out of service, No. 3 is to be used as shown on Figure 34. Sludge transfer pump Nos. 3 and 4 are equipped with variable speed drives. Pump speed is changed by means of push button controls located in motor control center No. 67CC located in the operating room of the incineration building. Pumping rates may thus be changed simply by pushing the appropriate button marked FAST or SLOW to increase or decrease pump speed. Speed control buttons should be "jogged" rather than held for long periods since excessive pump speed fluctuations with resulting wide pump rates are to be avoided. Selection of proper pump speed is facilitated by a level indicator mounted in the incineration building control room. Observation of this instrument as previously described will provide the required information to operators regarding need for pump rate changes.

The mixed thickened sludge is pumped through a 6-inch pipe to either the sewage or combination centrifuge or both. If both machines are in use, sludge flow can be equally divided between the two machines by means of weir valves located on the influent lines to the two machines. Each centrifuge is equipped with an ammeter located in the furnace control panel. Since the current drawn is proportional to the solids loading, balancing the two ammeters by valve manipulation will result in an approximate equal sludge flow to each machine in use.

Sewage sludge is dewatered by the centrifugal forces created in the centrifuges. The sludge cake is forced from the centrifuge by a rotating screw called the scroll and falls by gravity from the discharge part of the machine directly on the sludge furnace conveyor feed belt in the case of the sewage centrifuge. In the case of the combination centrifuge, sludge cake falls into the cross-feed conveyor which in turn conveys the cake to the sludge furnace conveyor feed belt. If the combination centrifuge is in use dewatering sludge, care must be taken to see that the cross-feed conveyor is operating in the proper direction; otherwise, sewage sludge can be discharged to the lime furnace. Liquid removed from the sludge by the centrifuges, referred to as centrate, is discharged back to the plant headworks for complete retreatment.

Burning. The sludge furnace conveyor feed belt may be run either forward to discharge into the furnace or reverse to discharge into a chute located outside the building. The reverse operation is never to be used unless the sludge furnace is out of operation and a truck is in position under the outside sludge discharge chute to catch the dewatered solids.

During normal operation sludge cake is fed to the sludge furnace, wherein the sludge is burned to ash.

Ash Disposal. Ash exits from the bottom of the furnace into the ash bucket elevator which in turn discharges ash into the ash screw conveyor. This conveys the ash to the exterior ash bin for storage until the ashes are trucked to ultimate disposal. Truck loading is accomplished by means of an ash conditioning screw conveyor which mixes a small amount of water with the ashes prior to discharge into the truck so as to minimize ash dust problems during the truck loading operation. Ash production during periods of maximum loading is anticipated to be approximately 5,800 lbs. per day. Since the ash is very light and fluffy, this weight may be translated to a volume of approximately 250 cubic feet per day. Maximum effective storage provided in the ash hopper will be approximately 200 cubic feet or slightly greater depending on the angle of repose of the ash. It is probable that a 5-cubic-yard or smaller dump truck will be used to haul ash. This will mean that ash must be removed from the storage hopper approximately twice per day at maximum operating conditions. The entire sewage solids handling and incineration system is shown on Figure 68.

Lime Recalcining.

Lime Mud Thickening. Chemical sludge (lime mud) is withdrawn from the chemical clarifier on a continuous basis as previously described. This sludge is discharged to the lime mud thickener located adjacent to the incineration building. This machine will concentrate the lime sludge from the influent feed concentration of 0.5 to 1 percent solids to approximately 8 percent solids. The machine is an industrial type circular thickener, 30 feet in diameter with a 3-inch per foot bottom slope. Settled lime sludge is scraped to a center hopper by rotating plows. The entire mechanism is supported by a bridge. A lifting device is provided which is capable of lifting the entire rotating plow assembly a maximum of one foot above the tank floor. In the event of overloading of the thickener mechanism, this feature enables the operator to free the plow mechanism by lifting and then slowly lowering the plows into the sludge layer after thickener rotation has been reestablished.

Thickened lime mud is to be withdrawn from the thickener by means of one or both of the variable speed spent lime pumps located in the basement of the incinerator building. These pumps are Wemco torque-flow pumps designed to handle the lime mud. Pumping rates are remotely adjusted by means of electric speed control devices actuated by push buttons located in the incinerator control panel. Under maximum load conditions, a flow rate of approximately 40 gpm of spent lime will result in a solids content of about 8 percent from the thickener. This flow may be easily handled by one of the two pumps operating alone; thus 100 percent standby pump capacity is available. Normally, only one pump will be used at a time; however, the two pumps should be alternated so as to equalize wear. It is important that the lime sludge be removed from the thickener sufficiently rapidly to prevent creation of a deep sludge layer in the thickener since this condition could result in overloading and possible failure of the thickener mechanism. The mechanism is equipped with a torque overload cutout which shuts off power in the event of overload and alarms this condition by means of the annunciator located in the furnace control panel. In the event of overload failure, sludge fed to the thickener should be immediately stopped and the thickener plow mechanism lifted. Rotation should then be reestablished, sludge pumping rate from the thickener increased, and the plows then lowered. Sludge fed to the thickener may then be reestablished and the sludge withdrawal rate may progressively be decreased.

Overpumping of sludge from the thickener should also be avoided since this can result in overloading of the lime sludge dewatering equipment and subsequent increased fuel costs in the recalcining system. Pumping rates up to 50 gpm to the lime centrifuge should not cause any operating difficulties, and because of this it is probably preferable to overpump to some extent rather than run the risk of thickener overload caused by underpumping. As operating experience is gained, it will be possible to more accurately judge pumping rates. Expected normal operation would be to adjust pumping rate to the thickener so as to maintain an influent solids concentration of about 0.75 percent solids and concentration of about 8 percent solids in the sludge removed. This in theory requires a sludge withdrawal rate of about 10 percent of the flow rate to the lime mud thickener. Since the possibility exists that the spent lime pump piping systems may plug, convenient places are provided for flushing, using either air or water. The discharge piping system is also equipped with a sensing device which activates an alarm on the annunciator panel in the event of pumping failure. In the event that this alarm sounds, sludge pumping must be reestablished as quickly as possible in order to prevent possible lime mud thickener overload.

Dewatering Lime Sludge. Spent lime sludge is dewatered by means of either or both of two centrifuges; namely, the lime sludge or the combination centrifuge. Normally, the lime sludge centrifuge is to be used alone. The combination centrifuge is used normally only in case of failure of the lime sludge machine. Operation of the centrifuges is the same as has been previously described for sewage sludge dewatering except that if the combination machine is used, care must be taken to operate the cross-feed conveyor so as to discharge to the lime furnace feed belt. Both centrifuges which can be used on lime sludge service are adequately sized to handle sludge rates up to twice those normally expected; accordingly, the use of both machines operating simultaneously on lime sludge service, while possible, is not normally anticipated.

Recalcining. Dewatered spent lime is discharged from the centrifuge either directly to the lime furnace feed belt or to the cross-feed conveyor thence to the feed belt. This belt normally operates in the forward direction to discharge dewatered lime sludge cake to the multiple hearth recalcining furnace. In the event of furnace shutdown, it is possible to operate the feed belt in the reverse direction in which case the sludge cake is then discharged into the outside spent lime sludge hopper provided. This is the only emergency outlet for spent lime sludge and this system must be used whenever lime feed is practiced during times of lime recalcining furnace breakdown. Dewatered spent lime sludge is removed from the storage hopper as required and trucked to disposal or it may be stockpiled for later reintroduction into the recalcining system by feeding the cake slowly into the lime mud thickener.

Spent lime sludge which is introduced into the recalcining furnace by the feed conveyor is subjected to high temperatures within the multiple hearth furnace and converted from sludge cake principally composed of calcium carbonate to calcium oxide. The principal reaction which takes place is as follows:

$$CaCO_3 + H_2O + \text{Heat} \rightarrow CaO + H_2O + CO_2$$

The by-products of water and carbon dioxide are emitted as gasses through the furnace stack. The stack gasses are wet scrubbed and the majority of the water is condensed and leaves in the scrubber drain system while the carbon dioxide is recovered for use in the recarbonation process.

The recalcined lime or calcium oxide exits by gravity from the lower furnace hearth and falls into a precooler called the thermal disc cooler. This device consists of a series of rotating water cooled discs which act to cool the extremely hot furnace discharge prior to conveying of the recalcined lime to storage. The thermal disc cooler discharges cooled recalcined lime through a rotary air lock into a pneumatic conveying system which then conveys the material to the recalcined lime storage bin for eventual reuse. This pneumatic conveying system uses compressed air as a motive force. Compressed air is provided by the small Roots type AF blower located in the basement of the incineration building. Diverter valves are provided in the discharge lines of the pneumatic conveying system which make possible discharge of recalcined lime into either storage bin in the event the recalcined bin becomes too full. Bindicator devices are provided which sound high and low bin level alarms on the annunciator in the furnace control panel. The lime storage bins are common vented through a vibrating filter which serves to remove lime dust from the exhaust air prior to its discharge to the atmosphere. This filter system is automatic in operation and uses compressed air from the plant air system as a motive power source for its vibratory filter cleaning mechanism.

There are a number of critical mechanisms involved in the handling of the recalcined lime discharge from the furnace. In order of flow, these are as follows:

1. Thermal Disc Cooler - This unit must have a supply of cooling water at all times that it is in operation. Cooling water failure could result in steam generation inside the closed system with the possibility of damage. Safety valves are provided to limit maximum pressures. Rate of cooling water flow is adjusted by means of a valve and a flow indicator is provided. Too little cooling water flow could result in elevated temperature of the unit discharge. Temperatures in excess of 600°F. will result in damage to the rotary airlock which discharges cooled recalcined lime to the pneumatic conveying system. A temperature sensing thermocouple measures the temperature of the cooled lime and will sound an alarm on the annunciator in the furnace control panel if dangerously high discharge temperatures occur.

2. Rotary Air Lock - This unit must never be subjected to temperatures in excess of 600°F. and must never be operated unless the air seal system is functioning. The rotary air lock uses teflon lined, hand lapped, bearings which must be kept purged with clean air at all times. A pressure switch automatically shuts off the rotary air lock drive motor in case of purge air failure.

3. Recalcined Lime Conveying System - This system must receive a supply of compressed air from its blower system continuously or plugging will result. In addition the exhaust air filter system must be operational. Failure of the blower system or the filter air supply system sounds an alarm and automatically shuts down the conveying system. Shutdown of the system then automatically shuts down the rotary air lock system described above.

The entire lime solids handling system is shown schematically on Figure 69.

Lime Reuse. Recalcined lime from the storage bin provided is reused as a coagulant as previously described. Recalcined lime should be reused at about the same rate as it is being produced by the furnace. Occasional observations of depth in the recalcined lime storage bin should be made for this purpose. Recalcined lime is withdrawn from the bottom of the bin, passes through an automatically controlled emergency shutoff knife gate and is metered into a lime slaker by a gravimetric lime feeder. This gravimetric feeder is automatically controlled by means of a pH signal derived from the primary clarifier effluent sampling system. In practice, the desired primary clarifier effluent pH is set on the appropriate pH indicating controller which then signals the gravimetric feeder to speed up or slow down as may be required. A pH of approximately 9.3 should be used as a set point. Lime feed from the gravimetric feeder falls into the recalcined lime slaker wherein it is automatically slaked and diluted to a milk of lime solution. Slaking water is automatically controlled by means of a torque activated valve supplied as a part of the slaker. The milk of lime solution from this slaker is conveyed by rubber hose to the lime slurry splitter box as shown on Figure 64. This splitter box divides the recalcined lime flow between the primary clarifiers and also splits a portion of the recalcined lime flow to the rapid mix chamber. An adjustable Cippoletti weir is used to control the portion of recalcined lime which is split to the rapid mix chamber. The following example will serve to further explain the feed system:

1. Assume the recalcined lime bin is nearly full and lime is being produced faster than it is being used. Also assume that the pH indicating controller which paces the recalcined lime gravimetric feeder is set at the normal position of pH = 9.3.

2. The problem obviously is that unless something is done to increase the feed rate of recalcined lime, the bin will fill thus plugging up the entire lime sludge handling system and causing a major catastrophe.

3. One solution would be to set the pH indicating controller to a higher pH - BUT this would cause primary effluent pH to rise thus probably killing the activated sludge and causing another catastrophe. This obviously is not a good solution to the problem.

4. Another solution would be to start diverting recalcined lime into the make-up lime bin. This would not cause any major operating difficulties but would result in some undesirable recycling of phosphate containing lime. Also, of course, this solution would only be feasible if sufficient volumes were available in the make-up lime bin. This is not a preferred solution to the problem.

5. The best solution is to simply open the adjustable Cippoletti weir in the lime slurry splitter box slightly. This will result in a larger portion of the recalcined lime being split to the rapid mix chamber. This causes an effective reduction in the lime feed to the primary clarifiers, which in turn causes the primary clarifier effluent pH to fall. The pH indicating controller senses this pH fall and automatically speeds up the recalcined lime gravimeter feeder, thus the usage rate of recalcined lime is increased to match or exceed the production rate. The increased portion fed to the rapid mix chamber causes a pH rise at that amount which in turn causes the make-up lime feeder to slow down, thus conserving the lime in make-up bin storage.

6. If the problem were too low a level in the recalcined lime bin, closing the adjustable Cippoletti weir will effectively reduce the use rate of recalcined lime.

Make-Up Lime Use. Under normal operating conditions it will always be necessary to feed some percentage of make-up lime in addition to the recalcined lime feed. The required make-up lime dosage is estimated to be approximately 100 mg/l or about 850 lbs of make-up lime per million gallons of flow. Make-up lime is fed from storage by a gravimetric feeder and slaker in the same manner as the recalcined lime. Control is maintained automatically by means of a second pH indicating controller which paces the make-up lime feed to the pH of the flocculation basin.

Make-up lime will be trucked to the plant in bulk tanker and unloaded to storage by means of a second pneumatic conveying system. This system has its own separate blower, rotary air lock, and vibrating filter equipment and is provided with electrical safety interlocks similar to those described for the recalcined lime system. Compressed air for the rotary air lock seals and the filter shaker system must be provided at all times when the system is in operation. This system also is equipped with diverter valves in the discharge lines, making possible discharge to either lime storage bin. Each of the two lime storage bins has an effective volume of approximately 900 cubic feet which provides storage for about 25 tons of bulk quicklime. This provides storage of from 7 to 10 days duration at maximum flow rates of 7.5 mgd through the plant.

CONTROL OF PLANT OPERATION

Primary Treatment.

Lime Application and pH. Lime application to the primary basins is controlled automatically by the recalcined lime pH indicating controller. This device should be set to a pH of 9.3 and it will in turn pace the recalcined lime feeder regardless of flow or other process variables. Recalcined lime should always be preferably used rather than make-up lime.

Sludge Withdrawal. Sludge withdrawal has been previously discussed and the methods outlined are to be preferred. Four sludge transfer pumps are provided. Any pump can be substituted to perform the duty of any other pump in the event of equipment failure. In the event that pump Nos. 1 or 2 must be replaced with pump No. 3 the following sequence should be used:

1. Set the HOA switch for pump No. 3 to "Off".

2. Set the lockout stop (LOS) for the pump to be replaced (No. 1 or No. 2) in the "Stop Lock" position.

3. Set the HOA switch of the pump to be replaced (No. 1 or No. 2) to the "Auto" position. This transfers the timer circuit of the pump being replaced to pump No. 3.

4. Set valves in pump room properly. See Figures 29 through 35.

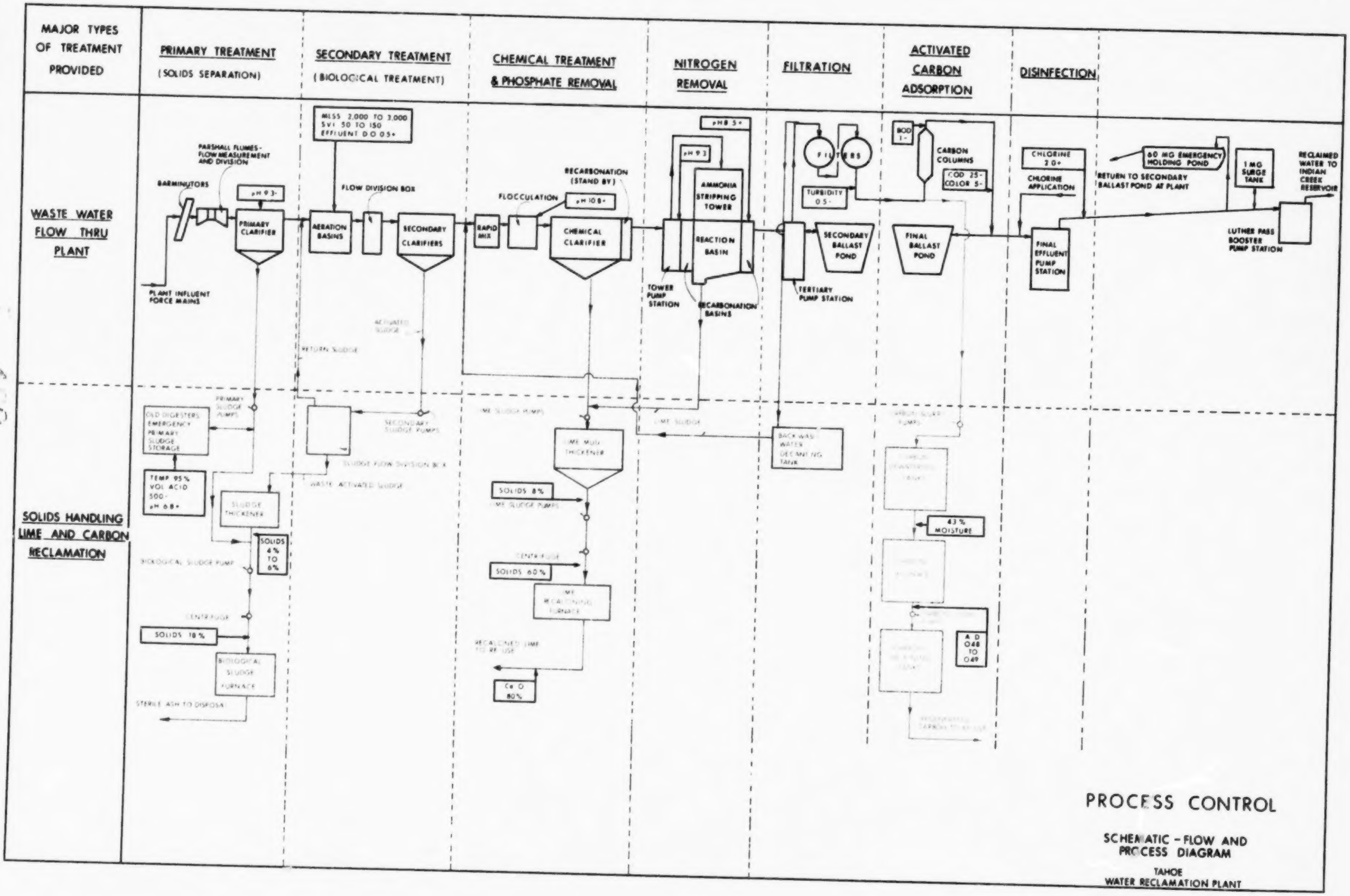
5. Set the selector switch for pump No. 3 to the No. 1 or No. 2 position (whichever pump is to be replaced).

6. Set the HOA switch for pump No. 3 to "Auto".

7. Check pump No. 2 LOS and place in unlocked position if necessary.

8. Pump No. 3 is now ready to run on a time cyclical basis using the timer of the pump which it replaces as a controller.

All sludge transfer pumps are electrically interlocked with the control system of the solids handling system. This means that in the event of any equipment failure in the biological sludge incineration system, all sludge transfer pumps will automatically shut down. When it is necessary to operate any sludge transfer pump when the biological sludge incineration system is shut down, it is necessary to bypass these electrical interlocks by switching the interlock selector switch for each sludge pump desired to be operated from the safe to the bypass condition. These switches are located in motor control center 67CC, one in each of the four sludge transfer pump starters. These selectors must always be in the "Safe" position at any time the sludge or combination centrifuge is in operation. They may only be placed in the "Bypass" position when sludge is being pumped elsewhere than to the incineration building. Failure to observe this precaution can result in pumping a stalled centrifuge completely full of sludge, thus causing physical damage to an expensive precision machine or at best necessitating complete disassembly of the unit for cleaning; a very disagreeable task requiring considerable time to perform.



PROCESS CONTROL

SCHEMATIC - FLOW AND PROCESS DIAGRAM

TAHOE
WATER RECLAMATION PLANT

Secondary Treatment.

Mixed Liquor Solids. Maintain as high as possible without upsetting final clarifiers. 2,500 to 3,000 mg/l total MLSS is recommended.

Load Factor. Maintain at 0.35 lbs BOD (primary clarifier effluent BOD) per pound of mixed liquor volatile suspended solids or greater. Ordinarily this would be achieved if the BOD loading to the aeration basins is on the order of 0.25 lbs/lb of MLSS, since MLSS are approximately 75 volatile. If necessary to keep load factor up, cut out of service aeration basins, and increase sludge wasting rates thus reducing MLSS concentration.

Sludge Volume Index. Maintain as low as possible. SVI of 100 or less should be attempted. SVI of 150 or greater will result in poor settleability of aeration basin mixed liquor. If SVI rises, increase recirculation rates; decrease sludge wasting; increase air supply to maximum; and immediately examine mixed liquor microscopically to determine, if possible, causes. Always consult chief operator if control measures fail to solve the problem. Make SVI and dissolved oxygen tests often during periods of upset.

Dissolved Oxygen. Maintain a minimum of 1.0 mg/l D.O. in aeration basin effluent. 1.5 to 2.0 mg/l is preferable. D.O. concentration in aeration basin effluent of greater than 2.0 mg/l serves no useful purpose and simply waste energy. Perform D.O. tests often.

Return Sludge. Return rates should be adjusted as required to prevent solids loss from final clarifiers and to maintain thickest possible sludge. With both final clarifiers in use, return rate from Secondary Clarifier No. 1 should be about 25 percent of total return sludge flow. This means that return sludge rate from Secondary Clarifier No. 2 should usually be about 3 times the rate from No. 1. Refer to Figure 13. Adjust overflow rings on drawoff pipes closest to center to pull more sludge than drawoff pipes near outer edge of clarifier. Clean rings as required. Adjust all rings to pull as thick a sludge as possible consistent with fast enough return rate to minimize solids loss.

Chemical Treatment.

Flocculation Basin, pH. The pH in the flocculation basin is an important control point with regard to phosphate and nitrogen removal. For ammonia stripping, a pH of at least 10.8 is desirable (see Figure 75). For maximum phosphate removal, a pH in the 11.0 to 11.5 range is needed (see Figure 76). A total lime dose of 400 mg/l will give a pH of about 11.5 in the treated waste water.

The pH in the flocculator basin is automatically controlled. The desired pH value is set on the floc basin pH controller, then the makeup lime feeder will add enough lime ahead of the flocculation basin to make the pH in the flocculation basin match the pH value set on the controller.

Recarbonation (Alternate). When the two-stage recarbonation facilities beneath the ammonia stripping tower are not in use, the chemical clarifier effluent will be recarbonated in a single stage in the chemical clarifier effluent launder. A sample of the recarbonated water will be pumped continuously to a pH recorder-controller. The controller would be set for a pH in the range of 8.5 to 9.0. The pH of the recarbonated water would then be matched to this value set on the controller by means of a regulating valve on the carbon-dioxide compressor discharge line. The method by which this valve regulates the pH is to allow escape of the excess carbon dioxide above that required to maintain the desired pH from the discharge line to the atmosphere. If the pH rises above the set value, then additional compressor capacity must be put into service.

Ammonia Stripping.

Influent pH. The method of maintaining the influent pH to the ammonia stripping tower already has been discussed under "Flocculation Basin, pH."

Air to Water Ratio. Constant speed pumps are used to furnish water to the ammonia stripping tower. Enough pump units must be used to pump more water than the incoming plant flow. By means of a flap-gate between the tower pump sump and the tower effluent water in the primary recarbonation basin, some tower effluent is recirculated in order to match net tower output to plant throughput. This partial recirculation increases the hydraulic loading on the tower packing, decreases the air to water ratio, and increases the effective height of the tower (or number of droplet formations). The net effect of partial recirculation is beneficial, the effect of the increased number of droplet formations on ammonia release more than offsets the reduced efficiency resulting from greater hydraulic loading and lower air to water ratio. However, the recirculation ratio should be less than 1:1, which means that two tower pumps should not be used if one will handle the flow. On the other hand, all available draft fan capacity should be utilized except when reduction of air flow is necessary to prevent freezing in the tower.

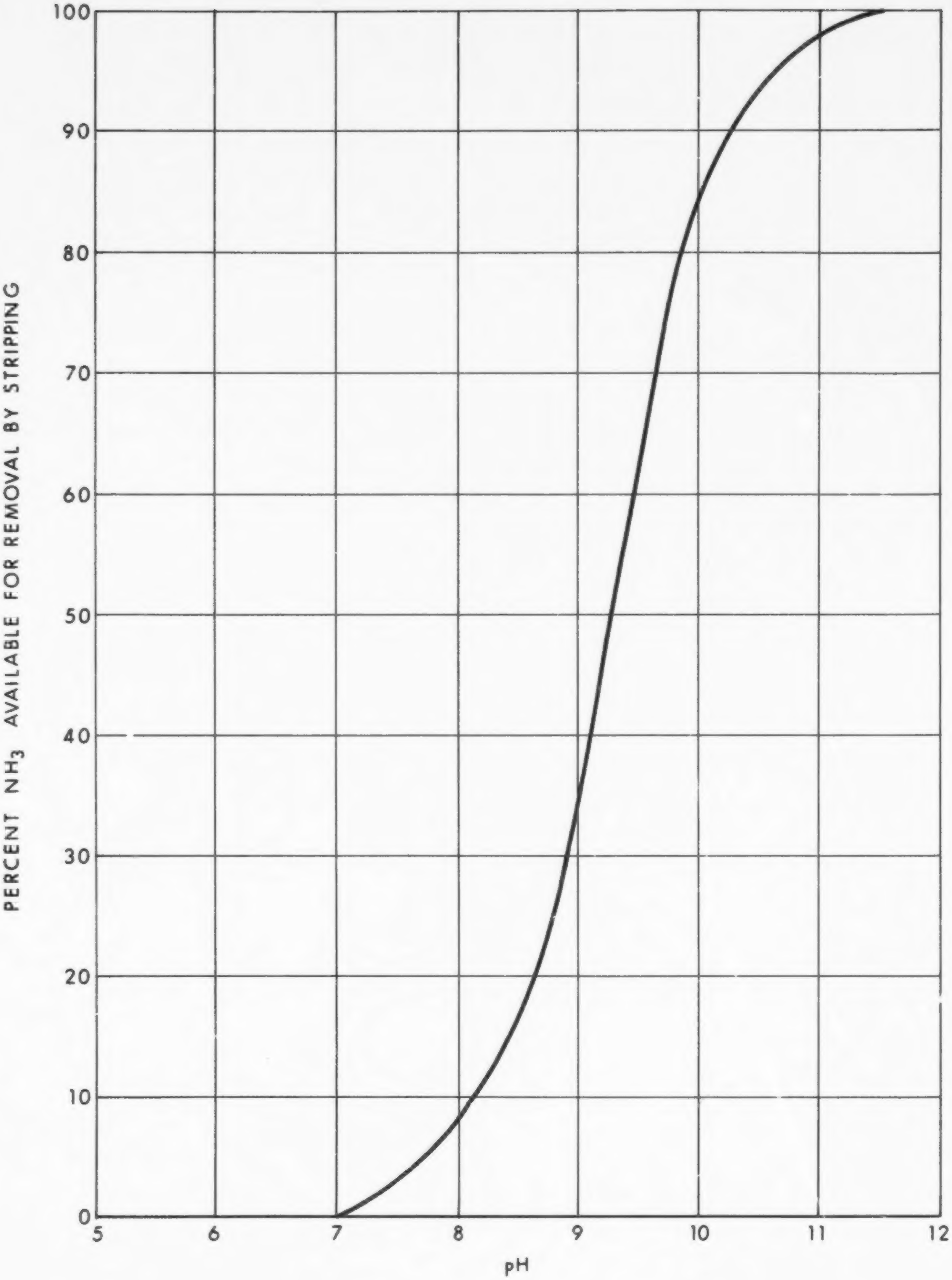
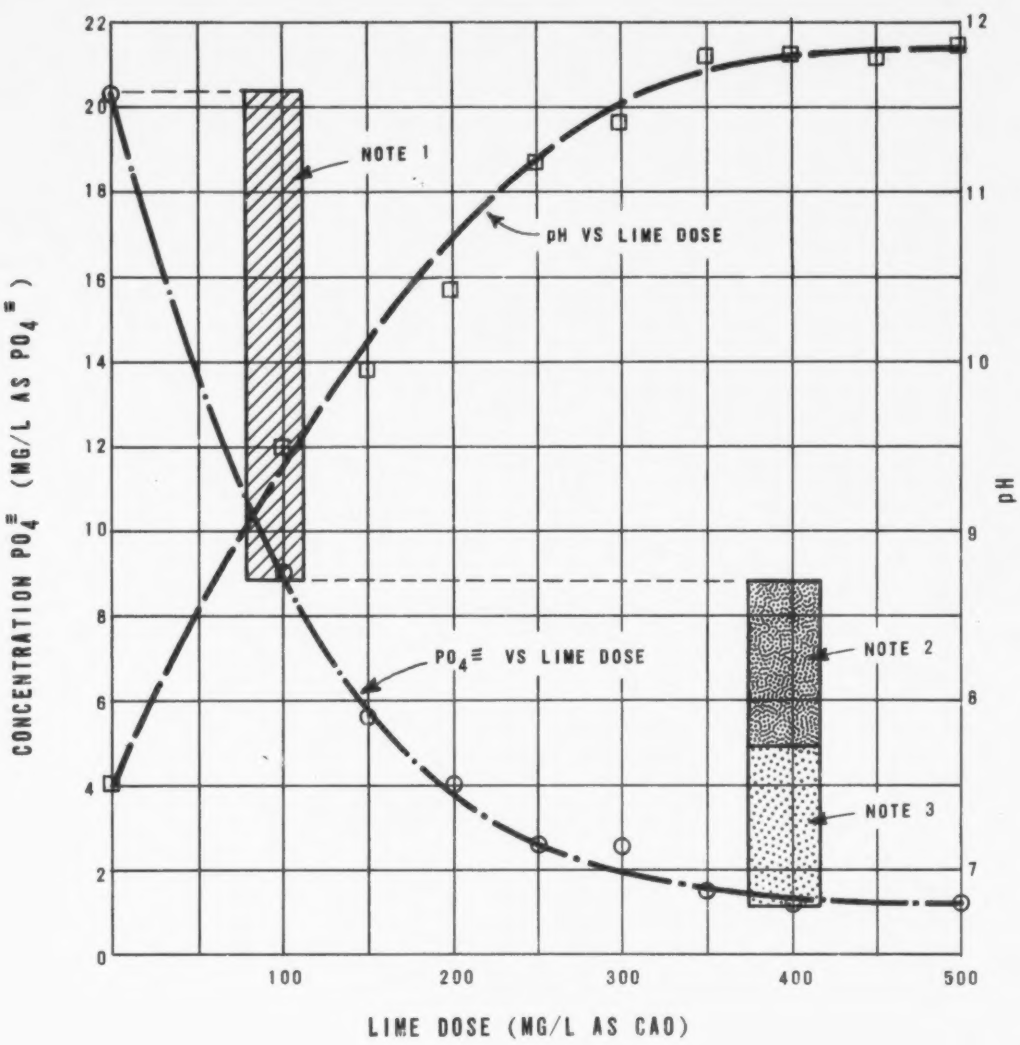


FIGURE 75

PERCENT AMMONIA AVAILABLE FOR REMOVAL BY STRIPPING AT 77° F. AS A FUNCTION OF pH



NOTES:

1. PHOSPHATE REMOVED FROM SEWAGE IN PRIMARY TANK (FIRST CYCLE).
2. INSOLUBLE PHOSPHATE IN RECLAIMED LIME REMOVED IN PRIMARY TANK IN RECYCLING.
3. INSOLUBLE PHOSPHATE IN RECLAIMED LIME IN CONTINUOUS RECYCLE TO CHEMICAL CLARIFIER.

FIGURE 76
PHOSPHATE CONCENTRATION AND pH
VS LIME DOSAGE AT SO. TAHOE P.U.D.
WATER RECLAMATION PLANT

Recarbonation (Two-Stage).

The total amount of carbon dioxide to both the primary and secondary recarbonation basins is regulated as described under "Recarbonation (Alternate)", that is, a sample of the water after secondary recarbonation is pumped continuously to a pH recorder-controller. The controller would be set for a pH in the range of 8.5 to 9.0. The pH of the water after secondary recarbonation would then be matched to this preset value by means of the regulating valve on the carbon dioxide supply line as previously described.

It is desirable to maintain the pH at 9.3 in the reaction basin following primary recarbonation. This must be done by manual adjustment of the butterfly valves on the carbon dioxide supply headers to the primary and secondary recarbonation basins, and by collecting "grab" samples from the reaction basin for pH testing. It is only the total carbon dioxide required to secure the desired final pH which is automatically controlled. This permits the same pH controller to be used to control either the normal two-stage recarbonation or the standby single-stage recarbonation merely by changing from the pH sample pump in the secondary recarbonation effluent box (normal) to the sample pump in the chemical clarifier effluent launder (standby).

Filtration.

The separation beds are backwashed on a time schedule which is set so that the separation beds are operated until the head loss exceeds a predetermined maximum (say 10 feet per bed or 20 feet for a pair of beds), or until there is a turbidity "breakthrough" which results in an effluent turbidity in excess of a desirable maximum (say 0.5 J.U.). When either of these events occur, the beds are backwashed. Each pair of beds in sequence is taken off the line, backwashed, and returned to service. If the filter runs are too short considering the condition of the influent water, it may be necessary to adjust the polyelectrolyte (or secondary flocculant) dosage. The secondary flocculant to be used initially is Purifloc N-11, an industrial grade polyelectrolyte. This material is employed as an aid to filtration in the separation beds. It does several things: it strengthens the floc; it provides a means of controlling the depth of floc penetration into the separation beds; it improves the clarity of the filtered water; and it increases the maximum permissible flow rates through the beds.

The dosages required for a given waste do not vary widely; normally they would lie in the range of 0.1 to 1.0 mg/l.

The amount of secondary flocculant needed increases with:

1. Higher flow rates through the separation beds;
2. Lower water temperatures;
3. Higher alum dosages; and
4. Higher turbidity in separation bed influent water.

The secondary flocculant dosage is determined as follows: The optimum dose is that which causes the maximum desired head loss (usually 10 feet) through each separation bed (20 feet total across both beds) to be closely approached at the same time that a turbidity "breakthrough" is impending in the second bed. In practice it is better to feed slightly more than the exact optimum amount. Increasing the dose above optimum accelerates the rate of head loss increase and may cause the filters to be backwashed due to head loss rather than "breakthrough." If the dose is too low, "breakthrough" will occur before maximum allowable head loss is reached. The word "breakthrough" as used here is a little misleading inasmuch as the increase in turbidity is gradual and some time is required for the turbidity to exceed satisfactory levels even after this so-called "breakthrough" has begun.

Ordinarily, more polyelectrolyte will be fed to the second bed of a pair than to the first. However, the dosage to each bed is independently controlled by the stroke setting on the feeder head serving a particular bed.

The dosage to each bed in a pair should be such that the head loss through each unit is about the same at the end of a run; that is, the head loss through each of the beds reaches the maximum (10 feet) at the same time.

In summary then: (1) the correct polyelectrolyte dose procuces the maximum head loss just slightly in advance of turbidity "breakthrough," (2) a high dose of polyelectrolyte causes the maximum head loss to occur too far in advance of breakthrough, and (3) a low dose of polyelectrolyte breakthrough to occur before the maximum allowable head loss is reached.

Some caution should be observed in reducing polyelectrolyte dosages as may be appropriate under improving applied water conditions, as there is some residual effect within the bed and some time lag before the full effect of the reduced dosage is realized. Most operators reduce the dosage in small increments over a period of several filter runs. The usual practice is to make a change and observe the effects over one to three runs before making a further reduction in feed. One idea is that the polyelectrolyte forms a film of microscopic thickness on the individual particles of media and that this film retains its adsorptive capacity for some length of time after formation. This may also explain the fact that momentary interruptions of polyelectrolyte are not critical, as again there appears to be a residual effect of previously applied material.

It should be noted that there does not appear to be a lag when the polyelectrolyte dosage is increased and changes may be made as rapidly as seems to be indicated by observed results.

The control of the polyelectrolyte feed becomes a very simple task once the operator learns to read and interpret the signs provided by the turbidity and head loss recorders.

Carbon Adsorption. There are just two controls required for operation of the carbon columns. The first is observation of head loss through each column. When the head loss exceeds a desirable maximum (say 10 feet), then the flow should be reversed through column to flush the upper (outlet) screens. This is the normal difficulty. If by some accident there is a concentration of carbon fines within the main body of carbon in the column, it may be necessary to increase the flow of water up through the column to about double the normal operating rate and to turn on the eight side jets. This will bring the fines to the top of the bed and may require flow reversal as described above to clear the top screens.

The second control for the carbon columns is to observe signs of carbon exhaustion as indicated by COD greater than 25 or color more than 5 in the carbon column effluent. This means that a slug (about 10 percent of the total volume in the column) of carbon should be withdrawn from the bottom of the column for regeneration, and an equal amount of regenerated or makeup carbon added to the top of the column.

Carbon Regeneration. Control of the carbon regeneration process is described on Pages C1 through C12 of this manual.

Sludge Incineration.

Solids Content of Thickened Sludge. Thickened waste activated sludge concentrations of 3.5 percent solids or greater should be fairly easily maintained at all times if the flotation thickener is properly operated and proper polyelectrolyte dosages are maintained. Primary sludge concentrations of ± 5.0 percent solids are likewise not difficult to achieve if sludge withdrawal rates are kept to a reasonable level. Efforts should always be made to keep sludge in the day tank as thick as possible by careful operating techniques. A minimum mixture concentration of 3.5 percent solids should be maintained. There is no practical upper operating limit since the pumping equipment can easily handle solids concentrations which are in excess of those obtainable from the sludge thickening equipment. Operators should always be aware that each extra gallon of unnecessary water pumped to the incineration system will require considerable wasted fuel for its evaporation.

Solids Content of Dewatered Sludge. Centrifuge operation should be controlled so as to produce a minimum solids concentration of 18 percent. Higher solids concentrations will at times be possible and should be preferred as long as the centrate (liquid effluent from the centrifuges) does not become too loaded with fine solids. Solids concentrations of greater than 4,000 mg/l in the centrate are to be avoided since they may cause difficulties particularly in the chemical clarifier. One centrifuge operating alone and without polyelectrolyte feed should be able to handle any loads imposed by flows up 4.0 mgd to the plant. At flow rates greater than this, two centrifuges should preferably be used, or, as an alternate, polyelectrolyte may be fed to a single machine handling the entire load. Proper polyelectrolyte types and required dosages can only be determined by experimentation and testing after operation has begun. Centrifuge polyelectrolyte feed mixing and pump facilities are provided on the third floor of the incineration building. A variable speed Moyno pump is used to feed the stock solution. This pump is equipped with a remotely controlled variable speed drive so that feed rates may be changed by manual operation of push buttons located in the furnace control panel.

Lime Recalcining. Solids content of thickened lime sludge - sludge withdrawn from the lime mud thickener - should be maintained at about 8 percent solids concentration. Under normal conditions this should require a lime sludge pump rate of about 10 percent as great as the rate of flow to the lime mud thickener. Two lime sludge pumps are provided; usually one pump will adequately handle all of the sludge. The pumps are equipped with remotely operated variable speed drives which are manually controlled by push buttons in the furnace control panel.

Solids Content of Dewatered Sludge. Centrifuge operation should be controlled so as to produce a spent lime cake of 60 percent or greater solids content. One centrifuge can adequately handle all of the lime sludge produced even at maximum plant flow rates up to 7.5 mgd. Centrate should preferably not exceed a solids content of 5,000 mg/l.

CaO Content of Recalcined Lime. Under normal operating conditions, the calcium oxide content of the recalcined lime should be 75 percent or greater. Lower values than this may be an indication of poor furnace operation, techniques such as overloading, or insufficient temperature. Higher values are to be preferred.

SAMPLING AND LABORATORY TESTS

Notes on the Collection and Handling of Wastewater Samples.

In the plant expansion, provisions have been made for automatic collection of samples composited in proportion o the varying plant flow. The following streams will be sampled automatically:

(1) raw sewage

(2) primary effluent

(3) secondary effluent

(4) chemical clarifier effluent

(5) separation bed effluent

(6) final effluent

In addition, certain grab samples from other locations in the process will be necessary. Grab composite samples may be desirable to evaluate the sludge streams.

In order to insure that the sampling program is optimized, the following items should be noted:

1. The composition of wastewater and sludge streams varies from hour to hour and day to day. Care, therefore, must be exercised in sampling. Analytical results are of questionable value when sampling is carelessly performed.

2. One of the frequent causes of error in sewage analysis is the failure to use a representative portion of the sample after it has been collected. Whenever the sample is handled, it should be agitated gently to obtain a uniform distribution of solids. When measuring for analysis or when measuring for the composite (see note No. 3), the solids should be kept in uniform suspension.

3. In order to decrease the number of analyses, individual samples may be made into composite samples for some purposes. In this case, the volume of the individual sample added to the composite should be measured in proportion to the rate of flow at the time of collection.

4. For plant efficiency tests, account must be taken of flowing-through time for the plant. That is, the same wastewater should be sampled throughout.

5. Composite samples for BOD should be kept iced during the period of collection. Analysis should be started as soon as the collection period is over. BOD samples should never be preserved with chemicals.

6. Samples for dissolved oxygen should be analyzed immediately after collection. These samples must be collected in such a manner as to prevent aeration which would change the oxygen concentration.

7. Noninterfering chemical sterilizing agents may be used for preserving samples for certain other determinations.

8. Samples should be taken in the flow and not in corners where stagnation may occur.

Tests for Control of Plant Operation.

Settleable Solids. By settleable solids is meant that portion of all solids present which will settle when the sewage is allowed to remain in a quiet state for a short period of time, usually one hour.

Procedure:

1. The Imhoff cone should be thoroughly cleaned and filled to the one liter mark with the thoroughly mixed sample.

2. The sewage is allowed to remain undisturbed for 3/4 hour and then the sides of the cone are gently stirred with a glass rod. After another 1/4 hour the volume of solids is read.

3. Record results as ml/l settleable solids.

Suspended Solids. Suspended solids include all material in suspension which can be removed by certain standard filters. "Settleable solids" are one constituent of "suspended solids."

Procedure:

1. Place a membrane filter or Whatman No. 1 fiber filter in a numbered aluminum dish, and obtain the tare weight of the combination by drying in the oven for 1/2 hour and cooling in the desiccator prior to weighing.

2. Place weighed filter in Millipore Filter Apparatus and apply suction.

3. Filter a well-mixed sample through the apparatus. (The volume of sample which can be readily filtered will depend upon the solids concentration. 100 ml samples can be used in most cases.)

4. Wash the filter with 10 ml distilled water.

5. Dry the filter in the aluminum dish in the oven at 103°C. for 1 hour.

6. Transfer the filter to a desiccator and let cool to room temperature before final weighing.

7. $\text{mg/l suspended solids} = \frac{\text{mg suspended solids} \times 1000}{\text{ml sample}}$

Total Solids. Total solids is the sum total of all settleable, suspended, and dissolved solids.

Procedure:

1. Prepare a 150-ml evaporating dish by heating in a muffle furnace at 600°C. for 15 minutes, cooling in a desiccator, and then weighing.

2. Place 100 ml of sample in the tared dish and evaporate over a steam bath.

3. Dry the dish in the oven at 103°C. for 1 hour.

4. Transfer the dish to the desiccator and let cool to room temperature before final weighing.

5. $\text{mg/l total solids} = \frac{\text{mg residue} \times 1000}{\text{ml sample}}$

$$\text{\% solids} = \frac{\text{mg/l total solids}}{10{,}000}$$

Total Volatile Solids. Total volatile solids is essentially a measure of the organic portion of the solids.

Procedure:

1. Ignite the residue remaining from the total solids tests for 15 minutes in the muffle furnace at 600°C.

2. Place dish in desiccator and let cool to room temperature before final weighing.

3. $\text{mg/l volatile solids} = \frac{\text{mg lost on ignition} \times 1000}{\text{ml sample}}$

Sludge Volume Index. The sludge volume index, SVI is the volume in ml occupied by one gram of activated sludge after settling the aerated liquor for 30 minutes. A one-liter sample is collected at the outlet of the aeration tanks, settled 30 minutes in a 1000-ml graduated cylinder and the volume occupied by the sludge reported in percent or ml. The sample is thoroughly mixed or an original sample taken, and the suspended solids determined and reported in percent by weight or mg/l.

$$\text{SVI} = \frac{\text{percent settling by volume}}{\text{percent suspended matter}}$$

$$= \frac{\text{ml settled sludge} \times 1000}{\text{mg/l suspended matter}}$$

SOUTH TAHOE PUBLIC UTILITY DISTRICT

SEWAGE SOLIDS - LAB ANALYSIS

Date: ____________________

Day: ____________________

TOTAL SOLIDS

Sample Point	Raw Sewage	Primary Eff.	Mixed Liquor	Secondary Eff.	Chem. Clar.	Final
Dish No.						
Weight of Dish + Residue						
Weight of Dish						
Weight of Solids						
Volume of Sewage, mls						
Total Solids, mg/l						

SUSPENDED SOLIDS

Sample Point	Raw Sewage	Primary Eff.	Mixed Liquor	Secondary Eff.	Chem. Clar.	Final
Crucible No.						
Weight of Crucible + Solids						
Weight of Crucible						
Weight of Solids						
Volume of Sample, mls						
Suspended Solids, mg/l						
Removal, % of Raw						

DISSOLVED SOLIDS

(mg/l Total Minus Suspended Solids)	________	________	________	________	________	____

SOUTH TAHOE PUBLIC UTILITY DISTRICT

SLUDGE ANALYSIS - LABORATORY WORK SHEET

Date: ____________________

Day: ____________________

Sample Point	Mixed Liquor	Float	Float + Raw	Centrifuged Organic Sludge	Incinerated Sludge	Centrifuged Lime Sludge	Recalcined Lime Sludge
TOTAL SOLIDS							
Dish No.							
Weight of Dish + Wet Sample							
Weight of Dish							
Weight of Wet Sample (a)							
Weight of Dish + Dry Sample							
Weight of Dish							
Weight of Dry Solids (b)							
Percent Solids (b)/(a) x 100							
VOLATILE SOLIDS							
Weight of Dry Solids (b)							
Weight of Dish + Dry Solids							
Weight of Dish + Ash							
Loss in Weight (c)							
Percent Volatile Solids (c)/(a) x 100							

Dissolved Oxygen - (Sodium Azide Modification of Winkler Method). The dissolved oxygen determination measures the amount of free atmospheric oxygen present in the water at the time of the determination. Since decomposition of organic matter proceeds constantly and with the absorption of oxygen (if any is present), unnecessary delay must be avoided between sampling and the start of the test.

Procedure for D.O. Test:

1. Sample directly into the glass stoppered bottle in such a manner as to prevent aeration. Fill completely and stopper, using care to prevent trapping air bubbles.

2. Remove stopper and add 2 ml of manganous sulfate solution from a pipette, placing tip of pipette below surface of liquid.

3. Without restoppering add 2 ml of the alkaline - iodide - azide reagent in the same manner.

4. Replace stopper without trapping air bubbles. Shake 20-25 seconds by inverting bottle about once each second. Let stand until the precipitate settles half way and leaves a clear supernatent.

5. Remove stopper and add 2 ml of concentrated sulfuric acid from a pipette. Restopper and mix well. Since the liberated iodine diffuses slowly, the shaking period should be prolonged for about 15 seconds in order to allow complete distribution of the iodine.

6. Measure out 200 ml of the treated sample into the 250-ml beaker and titrate with ~0.025 N sodium thiosulfate solution until a pale straw color is obtained. Add one or 2 ml of starch solution and continue the titration until the blue color which developed with the starch is destroyed.

7. D.O. mg/l = mls thiodulfate $\frac{(10)}{(\text{standardization factor})}$

Standardization of Sodium Thiosulfate Solution:

1. Place 200 ml standard iodate - iodide solution in 250-ml beaker.

2. Add 3 to 4 drops concentrated H_2SO_4.

3. Titrate with the sodium thiosulfate to a pale straw color, add 2 ml starch solution, and continue the titration to the removal of the blue color.

4. Standardization factor = mls thiosulfate to endpoint

Reagents for Dissolved Oxygen Test:

Manganous sulfate: Dissolve 480 grams of $MnSO_4 \cdot 4H_2O$, or 400 grams of $MnSO_4 \cdot 2H_2O$, or 365 grams of $MnSO_4 \cdot H_2O$ in distilled water, filter, and makeup to one liter.

Alkaline - Iodide - Azide: Dissolve separately in distilled water 700 grams potassium hydroxide (KOH), (or 500 grams of NaOH), and 150 grams potassium iodide (KI). Mix the two solutions, dilute to 950 ml, and cool. Then add slowly the sodium azide (NaN_3) (10 grams in 40 ml water) with constant stirring to avoid local heating. Make up 1 liter.

Starch solution: Mix 5 to 6 grams of potato starch with a small quantity of water and pour into 1 liter of boiling water. Mix, cool and add 1.25 grams of salicylic acid or 3 to 4 ml of chloroform for a preservative.

Standard sodium thiosulfate solution (.025N): Dissolve 6.205 grams of reagent grade sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) in distilled water and dilute to 1 liter with freshly boiled and cooled distilled water. Preserve by adding 0.4 grams sodium hydroxide per liter.

Alkaline - Iodide, Azide Reagent: Hach Chemical Company No. 277.

SOUTH TAHOE PUBLIC UTILITY DISTRICT

DISSOLVED OXYGEN RECORD

Date: ____________________

Day: ____________________

Time: ____________________

Sample Point	Tank No. 1	Tank No. 2	Tank No. 3	Tank No. 4	Tank No. 5	Small Sec. Clarifier	Large Sec. Clarifier
Initial Buret Reading							
Final Buret Reading							
Volume Titrant (V) Required, ml							
Strength Factor (S)							
D.O. mg/l $(V) \times \frac{10}{(S)}$							

Biochemical Oxygen Demand (BOD). Strictly speaking, the biochemical oxygen demand (BOD) of wastewater or polluted water is the amount of free oxygen required for the biological decomposition of organic matter under aerobic, standardized conditions. This quantity of oxygen is thus a measure of the concentration of organic material in the water.

Procedure:

The test is performed by supplying a known, sufficient amount of oxygen to the sample and measuring the amount left after 5 days.

Estimate of Strength: It will be necessary to make an estimate of the strength of the waste. The ability to do this is gained by experience, and even with an experienced analyst it is best to choose a range rather than a particular value.

The following table is a rough guide to the BOD values that might be expected from domestic sewage.

	5-Day 20°C. BOD
Raw domestic sewage	100 - 300 ppm
Settled domestic sewage	70 - 200 ppm
After secondary treatment	10 - 100 ppm
After tertiary treatment	0 - 10 ppm

To determine the BOD, it will be necessary to supply the waste with enough oxygen to allow odorless decomposition to proceed for 5 days at 20°C. without complete loss of oxygen. In fact, the most reliable values are those obtained when the supplied oxygen has been depleted at least 40% but not over 70%.

The method of supplying the oxygen is by the aerated dilution water. This water will ordinarily not contain over 8 ppm of oxygen. Therefore, to supply enough oxygen for a demand (BOD) of say 300 ppm, it will be necessary to use a great deal of dilution water and a small amount of waste. In other words, dilutions of the waste must be made.

The following table lists a series of dilutions and the BOD range that will be covered between a 40% and 70% depletion. The dissolved oxygen content of the dilution water is assumed to be 8.0 ppm.

Dilution	% of Waste	ppm BOD at 40% Depletion	ppm BOD at 70% Depletion
1 to 5	20	15	30
1 to 10	10	30	60
1 to 20	5	65	110
1 to 40	2.5	130	230
1 to 50	2	150	300
1 to 80	1.25	255	450
1 to 100	1	320	560
1 to 150	0.67	480	840
1 to 200	0.5	640	1120
1 to 300	0.33	960	1680
1 to 400	0.25	1280	2240

Dilution Technique: Determine the volume of each bottle by filling completely (including the neck) with water and measuring the water by pouring it into a graduated cylinder. Keep a permanent record of the volume of each bottle.

Assume the dilutions 1 to 5, 1 to 10, 1 to 25 are to be made. Assume further the volume of each bottle is exactly 250 ml. Proceed as follows: Fill by siphon two bottles with dilution water and label as "blanks". Partially fill three others which have been labelled, and transfer with pipette the carefully mixed waste in the following volumes:

Bottle Volume	Desired Dilution	Ml. Waste
250	1 to 5	50
250	1 to 10	25
250	1 to 25	10

Fill the bottles completely with dilution water (do not run over), stopper without trapping air bubbles, and store in the incubator with a water seal.

After five days determine the DO of each dilution and blank.

If there is any possibility that the original waste contains oxygen, a DO should be run on the sample at the start of the analysis. Sewage which has received secondary treatment or tertiary treatment and stream samples are likely to contain oxygen. The concentration must be known to compute BOD.

Reagents for BOD Test: All the reagents for the measurement of dissolved oxygen are required, plus the following dilution water.

Draw distilled water at least one week prior to use and begin aerating. Just prior to use, saturate with oxygen by aeration and then add the following four solutions:

1. Ferric Chloride: Dissolve 0.25 gram $FeCl_3 \cdot 6H_2O$ in distilled water and make up to one liter. Add 1.0 ml of this solution to each liter of dilution water.

2. Calcium Chloride: Dissolve 27.5 grams of $CaCl_2$ (anhydrous) in distilled water and make up to 1 liter. Add 1.0 ml of this solution to each liter of dilution water.

3. Magnesium Sulfate: Dissolve 22.5 grams of $MgSO_4 \cdot 7H_2O$ in distilled water and make up to one liter. Add 1.0 ml of this solution to each liter of dilution water.

4. Phosphate buffer stock solution: Dissolve 8.5 grams of KH_2PO_4, 21.75 grams of K_2HPO_4, 17.7 grams of Na_2HPO_4 (anhydrous) and 1.7 grams of NH_4Cl in about 500 ml distilled water and dilute to one liter. The pH of this buffer should be 7.2 without further adjustment. Add 1.0 ml of this solution to each liter of dilution water.

SOUTH TAHOE PUBLIC UTILITY DISTRICT

B.O.D. WORK SHEET

TYPE SAMPLE__________
PLACE COLLECTED__________
REPORT TO__________

DATE COLLECTED__________
COLLECTOR__________
DATE REPORTED__________

LAB NUMBER__________
DATE INTO INCUBATOR__________
DATE OUT OF INCUBATOR__________
ESTIMATED B.O.D.__________

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)*	(9)	(10)	(11)	(12)	(13)
					BURET READING							
PRESUM. B.O.D.	VOL. RAW SAMPLE ML.	VOL. SAMPLE DILUTED 1:10 ML.	BOTTLE NO.	BOT. VOL. ML.	FINAL	INITIAL	VOLUME THIO REQUIRED FOR SAMPLE, ML-(6)-(7)	D.O. OF DILUTION WATER IN BOTTLE = D.O. OF INCUBATED BLANK $\times\left[\frac{(5)-(2)}{(5)}\right]$	D.O. OF SAMPLE IN BOTTLE = D.O. OF RAW SAMPLE $\times\frac{(2)}{(5)}$	TOTAL D.O. AVAIL. IN BOTTLE = (9) + (10)	DEPLETION =(11)-(8)	B.O.D. = $\frac{(12)X(5)}{(2)}$
BLANK												
BLANK												
BLANK												
RAW SAMPLE												

* IF A 200 ML. PORTION OF IODINE SOLUTION IS TITRATED WITH 0.025N SODIUM THIOSULFATE THIS WILL EQUAL MG./LITER D.O.

Load Factor. The load factor in an activated sludge plant is defined as follows:

$$\text{Load Factor} = \frac{\text{pounds of BOD per day applied to aeration basins}}{\text{pounds of mixed liquor volatile suspended solids (V.S.S.) under aeration within aeration basins}}$$

$$\text{Load Factor} = \frac{\text{BOD (in mg/l) in primary clarifier effluent x raw sewage flow in mgd}}{\text{V.S.S. (in mg/l) in mixed liquor x aeration basin volume in million gallons}}$$

To maintain the nitrogen in the secondary effluent in the ammonia form (for subsequent removal by ammonia stripping) the load factor in the aeration tanks should be not less than 0.35.

Microscopic Examination of Activated Sludge. (From: "Microbiology for Sanitary Engineers" by R. E. McKinney)

Since the microorganisms follow definite patterns in all the activated sludge systems, it is possible to determine the operating characteristics of the various systems by making routine microscopic examinations of the activated sludges. The microorganisms act as instantaneous biochemical chemical indicators and eliminate the need for complex chemical tests, especially in small systems.

Activated sludge floc does not have a definite size or shape, but rather is a heterogeneous agglomeration of microorganisms. A good activated sludge will flocculate readily and produce an effluent that is free of dispersed bacteria. The absence of dispersed bacteria is usually accompanied by a relatively active population of stalked ciliated protozoa such as *Vorticella* and an occasional rotifer or the free-swimming ciliate, *Stylonichia*. Chemically, the 5-day BOD test of the settled effluent will be between 5 and 10 ml/l. If the sedimentation tank fails to yield good separation of the activated sludge, the 5-day BOD test will be about equal to the weight of volatile solids lost.

While it is important to recognize a good activated sludge under the microscope, it is also important to recognize the symptoms of a poor activated sludge and what is responsible for the problem. A sudden loss of protozoa can result from anaerobic conditions or toxic materials. If the lack of oxygen has killed the protozoa, it will be noted that the number of free-swimming bacteria has suddenly jumped. With toxic materials there will usually be no sudden increase in free-swimming bacteria, but rather a decrease. An activated sludge fed a toxic material will often look perfect and will have a sparkling effluent for a short period.

The growth of filamentous microorganisms such as actinomycetes or fungi is readily observable under the microscope. The filamentous microorganisms keep the floc from being compact. Filamentous forms usually result in nutritional deficiencies such as nitrogen and phosphorus, low pH levels, and low oxygen levels. The most critical factor for normal activated sludge systems is the low oxygen level, while industrial wastes normally suffer from nutritional deficiencies. It appears that the filamentous microorganisms are able to compete with the bacteria at oxygen tension levels between 0 and 0.5 mg/l. The bacteria begin to metabolize anaerobically, while the filamentous microorganisms continue with aerobic metabolism. The energy balance favors the filamentous forms in this region. If the system goes completely anaerobic, the bacteria will reestablish predominance since the filamentous microorganisms are generally strict aerobes.

Recently, it has been noted in the total oxidation systems that there is a tendency for filamentous microorganisms to predominate over a long period of operations unless sludge is wasted at reasonable intervals. It appears that the filamentous microorganisms are able to utilize slowly the inert polysaccharide material produced by the bacteria, thus giving the filamentous forms a source of food that is unavailable to the bacteria. Further research is needed on this point.

The best activated sludge has been produced in the total oxidation systems where the bacterial activity is so low that only a few rotifers are visible as living animals. The 5-day BOD test of such a system is usually under 5 mg/l.

As the organic load increases on the activated sludge, the number of bacteria in the system increases with stimulation of the free-swimming ciliates. A good activated sludge system with a BOD between 10 mg/l and 20 mg/l will have a high population of free-swimming ciliates and a high population of stalked ciliates. The two forms will be in almost equal predomination. Increasing the organic load will stimulate the free-swimming ciliates to very high levels. At relatively high organic levels the tiny flagellates appear in competion with the bacteria. It will be noted that the dispersed bacteria population is very high. One key bacterial form is the spirillum. The presence of large numbers of spirillum is good evidence of a poor activated sludge system.

Recognition of key microbial operation characteristics can come only from repeated observations of various activated sludges. With experience it is possible to analyze any activated sludge system just from microscopic examination of the activated sludge and a routine knowledge of how the system is operated. The importance of this technique to the plant operator cannot be overemphasized.

Chemical Oxygen Demand (COD). Chemical Oxygen Demand (COD) is a second measure of the organic strength of a wastewater. Potassium dichromate is used to chemically oxidize the organic matter, and excess dichromate is titrated.

1. Place 10-15 acid-rinsed and dried glass beads in each of the required boiling flasks.

2. Add one scoop of mercuric sulfate to each flask.

3. Place 10.0 ml of sample to each flask with a volumetric pipette. (See note.)

4. Slowly add 15 ml concentrated sulfuric acid (with silver sulfate) to each flask and swirl the mixture.

5. Add 5 ml of 0.025 N potassium dichromate to each flask, swirl the mixture, and place on hotplate for refluxing.

6. Prepare a distilled water blank to which all of the above reagents are added.

7. Reflux the solution for 2 hours.

8. Allow samples to cool and wash down condensers with distilled water.

9. Remove samples from reflux condensers and add 2 or 3 drops of Ferroin indicator.

10. Titrate samples with 0.005 N ferrous ammonium sulfate to the reddish brown endpoint.

To standardize the ferrous ammonium sulfate, place 5.0 ml of potassium dichromate in a flask, add 50 ml distilled water and 4 ml concentrated sulfuric acid, add ferroin and titrate as in step 10.

Note: If the COD of a given sample is greater than 70 mg/l, an aliquot should be prepared with distilled water so that the COD of the aliquot will be lower than 50 mg/l. The procedure outlined above should be followed using 10 ml of the diluted sample in step 3.

COD Reagents:

0.25 N Potassium Dichromate stock solution - Dissolve 12.259 grams $K_2Cr_2O_7$ (previously dried at 103°C. for 2 hours) in distilled water and dilute to one liter.

0.025 N Potassium Dichromate solution - Dilute 100 ml of the stock solution to one liter in distilled water.

Sulfuric Acid Reagent:

Dissolve 22 grams of silver sulfate in a 9 lb. bottle of concentrated sulfuric acid (reagent grade). Allow to stand for 24 hrs. until dissolution is complete.

0.25 N Ferrous Ammonium Sulfate stock solution - Dissolve 98 grams ferrous ammonium sulfate in distilled water. Add 20 ml concentrated sulfuric acid and dilute to one liter.

0.005 N Ferrous Ammonium Sulfate - Dilute 20 ml of the stock ferrous ammonium sulfate solution to one liter.

SOUTH TAHOE P.U.D.

COD ANALYSIS

DATE	FLASK NO.	DESCRIPTION	SAMPLE VOL.	ml $Fe(NH_4)_2(SO_4)_2$	a-b	c	COD = $\frac{(a-b)c \times 8000}{\text{SAMPLE VOL.}}$

Calcium Analysis.

Liquid Samples:

1. Add one ml 8 N KOH to 50 ml (or a smaller volume diluted to 50 ml) of sample.

2. Add one level spoonful of Calver II.

3. Titrate with standard Titraver solution to color change.

4. $\text{mg/l Ca}^{++} = \frac{(400)\ (\text{mls titrant})}{(\text{mls sample})}$

Solids Samples:

1. Place a small sample (1 gram) in the 103°C. oven in a tared dish for 1/2 hour, then allow to cool in desiccator.

2. Obtain weight of dried sample.

3. Dissolve sample in one liter distilled water.

4. Perform titration as above.

5. $\%\ \text{Ca}^{++} = \frac{(\text{mg/l Ca}^{++})}{\text{mg sample}}\ (100)$

Reagents for Calcium Analysis:

Calver II Indicator Powder - Hach Chemical Company Catalog No. 281.

Standard Titraver Solution - Hach Chemical Company Catalog No. 205.

8 N Potassium Hydroxide - Dissolve 448 grams KOH in 600 ml distilled water and dilute to one liter.

SOUTH TAHOE PUBLIC UTILITY DISTRICT

CALCIUM CONCENTRATION WORK SHEET

Date: ____________________

Day: ____________________

LIQUID SAMPLES:

Sample Point	Raw Sewage	Primary Effluent	Chem. Clar. Effluent	Lime Mud Thickener Effluent	Lime Mud Centrifuge Centrate	Recarbonated Effluent	Final Effluent
(a) mls sample							
(b) mls titrant							
mg/l Ca^{++} (a) x (b) x (0.16)							

SLUDGE SAMPLES:

Sample Point	Lime Mud Thickener Sludge	Centrifuged Lime Sludge	Recalcined Lime	Other
(a) mls sample				
(b) mg sample				
(c) mls titrant				
mg/l Ca^{++}(a) x (c) x (0.16) or % Ca^{++} $\frac{(c)}{(b)}$ x (800)				

Calcium Lost = mg/l Ca^{++} in final effluent minus mg/l Ca^{++} in raw sewage = ____________________ mg/l

Pounds Calcium Lost/Day = mg/l lost x (million gallons treated) x (8.34) = ____________________ lbs/day

The Iodine Number of Activated Carbon. The Iodine Number is defined as the milligrams of iodine adsorbed by one gram of carbon when the iodine concentration of the residual filtrate is 0.02 normal.

Procedure:

1. Grind a representative sample of carbon until 90% or more will pass a 325-mesh sieve (by wet screen analysis).

2. Dry the sample for a minimum of three hours in an electric drying oven maintained at 150°C.

3. Weigh 1.000 gram of dried pulverized carbon (see Note 2).

4. Transfer the weighed sample into a dry, glass-stoppered, 250-ml Erlenmeyer flask.

5. To the flask add 10 ml of 5%-wt HCl acid and swirl until carbon is wetted.

6. Place flask on hotplate, bring contents to boil and allow to boil for only 30 seconds.

7. After allowing flask and contents to cool to room temperature, add 100 ml of standardized 0.1 normal iodine solution to the flask.

8. Immediately stopper flask and shake contents vigorously for 6 minutes.

9. Filter by gravity immediately after the 6-minute shaking period through an E & D folded filter paper.

10. Discard the first 20 or 30 ml of filtrate and collect the remainder in a clean beaker. Do not wash the residue on the filter paper.

11. Mix the filtrate in the beaker with a stirring rod and pipette 50 ml of the filtrate into a 250-ml Erlenmeyer flask.

12. Titrate the 50-ml sample with standardized 0.1 normal sodium thiosulfate solution until the yellow color has almost disappeared.

13. Add about 2 ml of starch solution and continue titration until the blue indicator color just disappears.

14. Record the volume of sodium thiosulfate solution used.

15. Calculate the Iodine Number as follows:

$$\frac{X}{m} = \frac{A - (2.2B \times \text{ml of thiosulfate solution used})}{\text{weight of sample (grams)}}$$

$$C = \frac{N_2 \times \text{ml of thiosulfate solution used}}{50}$$

$$\text{Iodine Number} = \frac{X}{m} D$$

X/m = mg. iodine adsorbed per gram of carbon
N_1 = normality of iodine solution
N_2 = normality of sodium thiosulfate solution
A = $N_1 \times 12693.0$
B = $N_2 \times 126.93$
C = residual filtrate normality
D = correction factor (obtained from attached graph)

Notes on Method:

1. The capacity of a carbon for any adsorbate is dependent of the concentration of the adsorbate in the medium contacting the carbon. Thus, the concentration of the residual filtrate must be specified, or known, so that appropriate factors may be applied to correct the concentration to agree with the definition.

2. The amount of sample to be used in the determination is governed by the activity of the carbon. If the residual filtrate normality (C) is not within the range 0.008 N to 0.035 N, given on the Iodine Correction Curve, the procedure should be repeated using a different size sample.

3. It is important to the accuracy of the test that the potassium iodide to iodine weight ratio is 1.5 to 1 in the standard iodine solution.

Reagents and Equipment:

Hydrochloric acid, 5%-wt - To 445 ml of distilled water add 55 ml of reagent-grade concentrated hydrochloric acid.

Sodium thiosulfate, 0.1 normal - In a one-liter volumetric flask dissolve 24.82 grams of reagent-grade sodium thiosulfate crystals ($Na_2S_2O_3.5H_2O$) in distilled water. Add about 0.1 gram of reagent-grade sodium carbonate and dilute to the one-liter mark. This solution should be allowed to stand for a few days before standardizing.

Standardize with reagent-grade metallic copper. Dissolve about 0.2 gram of copper, weighed to the nearest 0.1 mg, in 5 ml of concentrated nitric acid and boil gently to expel brown fumes. Dilute to about 20 ml with distilled water and add ammonia water dropwise until the solution is a deep blue color. Boil again until the odor of the ammonia is faint. Neutralize with acetic acid until the precipitate which forms with the acid dissolves and add 5 or 6 drops in excess. Again bring to boiling. Cool to room temperature. Add solid potassium iodide in sufficient amount to redissolve the copper iodide precipitate which forms. Titrate with sodium thiosulfate until the iodine fades to a light yellow color. Add starch indicator and continue the titration by adding the thiosulfate dropwise until a drop produces a colorless solution. Calculate the normality of the sodium thiosulfate as follows:

$$\text{Normality of sodium thiosulfate} = \frac{\text{weight copper}}{\text{ml thiosulfate} \times 0.06354}$$

Iodine Solution - Dissolve 127 grams of reagent-grade iodine and 191 grams of potassium iodide in distilled water. (See Note 3.) Dilute to one liter in a volumetric flask. To standardize the iodine solution, pipette 25.0 ml into a 250-ml Erlenmeyer flask and titrate with the standardized 0.1 N sodium thiosulfate. Use the starch indicator when the iodine fades to a light yellow color. Then finish the titration by adding the thiosulfate dropwise until a drop produces a colorless solution.

Calculate the normality of the iodine solution as follows:

$$\text{Normality of iodine solution} = \frac{\text{ml thiosulfate} \times \text{normality thiosulfate}}{25}$$

Starch Indicator - Mix one gram of soluble starch with a few mls of cold water. Pour the mixture into one liter of boiling water and allow boiling to continue for a few minutes. This solution should be made up fresh daily for best results.

Filter Paper - E & D, folded filter paper, 18.5 cm, No. 192. Burrell Corporation Catalog No. 34-390.

Standardization:

Thiosulfate

$$N_2 = \frac{\text{ml biniodate used \_\_\_\_\_\_ X 0.10}}{\text{ml thiosulfate \_\_\_\_\_\_}} = \_\_\_\_\_\_\_\_\_\_$$

Iodine

$$N_1 = \frac{\text{ml thiodulfate \_\_\_\_\_\_ X } N_2}{\text{ml of iodine used \_\_\_\_\_\_\_}} = \_\_\_\_\_\_\_\_\_\_$$

Apparent Density Test for Activated Carbon. For this test procedure, see page C-6 of the section on Activated Carbon Treatment of this Manual. Also refer to Figures C-4 and C-5 of the same section.

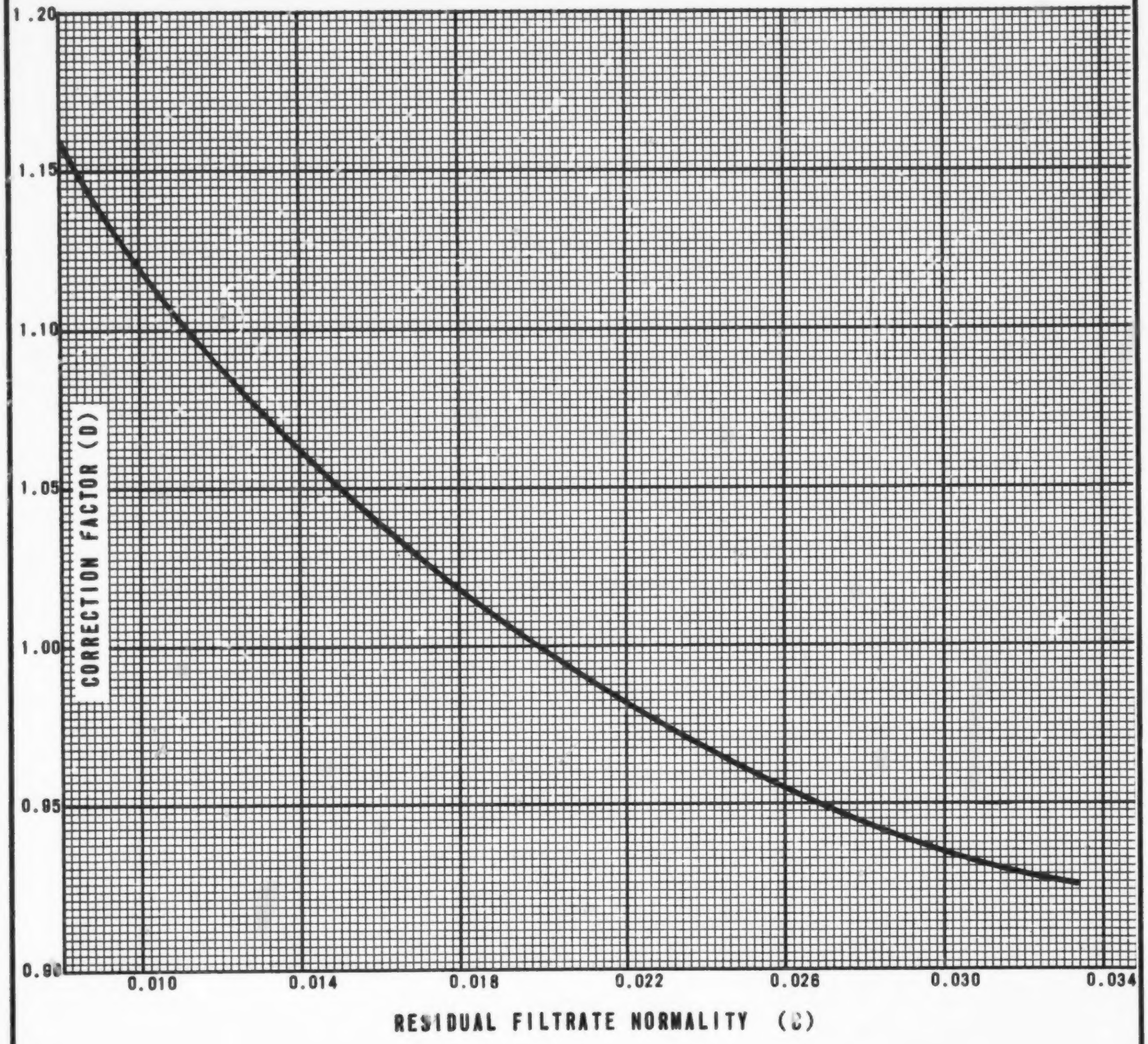


FIGURE T-1

IODINE CORRECTION CURVE

Volatile Acids in Digesting Sludge. During first stage digestion, part of the carbonaceous material is converted to the carbon-containing fatty acids. If the concentration of such acids is allowed to become excessive (about 1000 ppm), the pH of the sludge drops to undesirable levels and second stage or alkaline digestion with methane production will be very difficult to start and maintain.

The first six lower molecular weight fatty acids are termed volatile acids because they have a high vapor pressure and can be removed from water solution by distillation. The boiling points are generally higher than water but due to the high vapor pressure the vapor is carried over by steam from the boiling water. Recovery of the acids by the method below is not complete and a factor of 0.7 is usually applied.

Equipment and Reagents Required:

Distilling flask - 500 ml
Condenser with water jacket
Receiving flasks, graduated cylinders, burette, pipetts
Concentrated sulfuric acid
Standard sodium hydroxide solution, 0.117 normal
Phenolphthalein indicator solution

Procedure:

1. Using a graduated cylinder, transfer 50 ml or more of freshly drawn sludge to the distilling flask. (The size sample will depend on the volatile acid content. If the acid content does not exceed 2000 ppm, it would be best to use a 100-ml sample.)

2. Add 2.5 ml concentrated sulfuric acid and dilute to 200 ml with water.

3. Start cold water flowing through the condenser and connect it to the flask.

4. Distill over 150 ml at the rate of 4 to 5 ml per minute.

5. Titrate the entire distillate with 0.117 normal sodium hydroxide using phenolphthalein as an indicator. The end point is the first pink coloration which disappears on standing a short time due to CO_2.

Calculation:

ppm volatile acids expressed as acetic acid =

$$\text{ml } 0.117 \text{ N NaOH} \times 7 \times \frac{1000}{\text{ml sample}} \times \frac{1}{.7}$$

$$= \text{ml } 0.117 \text{ N NaOH} \times \frac{10000}{\text{ml sample}}$$

Colorimetric Determination of pH. Technically, pH is the measurement of the acid ion concentration of a solution. It is defined as the logarithm of the reciprocal of the hydrogen ion concentration.

For all practical purposes, pH simply measures the comparative or relative acidity or alkalinity of water. It does not measure the total amount of acid present but merely the intensity. A thermometer will not tell us how much heat a body contains but it does tell us how intense the heat is. When the thermometer reads 100°F., we say it's hot. If it reads 0°F., it's cold. At 75°F., we say it is about right. We have learned to use the thermometer and to decide from the scale reading whether it is relatively hot or cold.

pH measurement is exactly like this. The pH scale is divided into 14 units, starting at 0 and running to 14. Each unit is further divided into ten units so that the reading can be made to a tenth of a unit. It has much more meaning to say the pH is 7.3 than to say the pH is between 7 and 8. At the midpoint of the scale, or at pH 7, the water is neither acid not alkaline, but is exactly neutral. pH readings from 0 to 7 comprise the acid side of the scale. As the pH becomes less than 7 and approaches 0 it indicates increasing acidity. A pH of 6 indicates slight acidity, a pH of 4 moderate acidity, and a pH of 2 indicates strong acidity. The pH range from 7 to 14 is the alkaline side of the scale and indicates increasing alkalinity as we move from pH 7 toward pH 14. A pH of 8 indicates a slightly alkaline solution, a pH of 10 a moderately alkaline solution and a pH of 12 a strongly alkaline solution.

The colorimetric determination of pH depends on matching colors produced by dyes added to the liquid under examination with colors of standard discs or vials supplied with the equipment. Such equipment ordinarily consists of standard color discs, one for each 0.2 pH within the range of the equipment; one or more bottles of prepared dye (indicator) and appropriate tubes for containing the sample to be tested. Specific instructions are furnished with each outfit.

Procedure: (Hellige Comparators) - Estimate approximate pH of sample. Choose appropriate disc and place in comparator. Measure 10 ml of sample into each comparison tube. To one tube add the proper amount of appropriate indicator. Use pipette or calibrated dropper for adding indicator. Mix by whirling. Place tubes in comparator (tube with indicator on right) and turn disc until color match is obtained. If colors do not match exactly, use value between two adjacent standards. Use indicator solution prepared by the manufacturer of the pH outfit. Keep comparison tubes clean and protect standards and indicator from light when not in use. Note that the ranges overlap. Readings at extreme ends of the range are inaccurate. In such cases use the next higher or next lower range.

Notes on Water:

Source of Hydrogen Ions - Hydrogen ions in water are derived from (a) water itself, (b) free carbon dioxide, (c) bicarbonate ions, (d) acid salts such as alum and copperas, and (e) free mineral acids.

Purpose of Test - (1) Control of coagulation, (2) control of lime application, (3) control of recarbonation and (4) control of corrosion.

Notes on Sewage:

The pH of sewages and sludges depends considerably upon dissolved gases and specific states of decomposition. Therefore, care must be exercised when testing materials of this type to avoid unnecessary agitation, aeration, or delay in carrying out the test. The difficulty in comparing samples with standards when testing turbid liquids is usually fairly well obviated by the use of the turbidity compensators furnished with most makes of equipment. For determining the pH of sludges, however, additional means must be employed. The dilution technique described below is usually satisfactory for such materials.

Dilution Procedures:

An appropriate volume of the sludge to be tested is diluted with up to ten times its volume of distilled water and mixed gently. This mixture should then be allowed to settle. As soon as a sufficient layer of relatively clear liquid is available from the upper portion of the mixture, this liquid shouldbe withdrawn and its pH determined, using the regular procedure. Under no conditions should sewage or sludge samples be filtered prior to a pH determination.

Alkalinity.

Procedure: Alkalinity is determined by titration with a strong acid to the phenolphthalein (pH 8.3) and methyl orange (pH 4.5) endpoints.

1. Place a 100-ml sample of water in a 250-ml beaker, and place pH electrodes in the beaker, noting the initial pH.

2. While providing constant agitation, slowly add .02 N H_2SO_4, and record volume of acid necessary to lower the pH of the sample to 8.3 and 4.5.

3. (a) Phenolphthalein alkalinity; $\text{mg/l} = \dfrac{\text{mls } H_2SO_4 \text{ to pH } 8.3}{\text{mls sample}} (1000)$

(b) Total alkalinity, $\text{mg/l} = \dfrac{\text{mls } H_2SO_4 \text{ to pH } 4.5}{\text{mls sample}} (1000)$

Colorimetric Measurement of Chlorine Residual. Chlorine residual simply means the amount of chlorine, either as free chlorine or as chloramines, present in the water at the time and place of measurement.

The amount of chlorine added to the water can be readily controlled by means of various types of chlorine feeders. If nothing happened to the chlorine no more control would be necessary to insure safe disinfection of the water. However, chlorine is used up by bacteria and various forms of organic matter and iron and manganese. Therefore, it is necessary to measure the amount of chlorine present in the water at various places and at various times. Complete disinfection is not obtained unless chlorine is present in sufficient amounts at all times in all portions of the water.

Fortunately, a simple method exists for the measurement of chlorine concentration in water. This method is known as the ortho-tolidine method for chlorine residual, and by following directions closely, accurate results can be obtained. Ortho-tolidine is a complex organic compound which, in acid solution, reacts with chlorine to give a characteristic yellow color, the intensity of which increases with increasing chlorine concentration. With free chlorine the reaction is instantaneous and the color "flashes". A time interval of about five minutes is required for ortho-tolidine to react with chloramines. The color, however, is the same.

Chloramines are compounds formed when free chlorine is allowed to come in contact with ammonia. Ammonia may be naturally present in the water or it may be added. These compounds, while they produce more lasting residuals, generally are not considered to be as effective germicidal agents as free chlorine. A greater length of time is required for chloramines to kill bacteria than for free chlorine in the same concentration.

In some waters, there are present certain substances which interfere with the ortho-tolidine test. Iron in concentration of more than 0.3 ppm, manganese greater than 0.01 ppm, and nitrate nitrogen greater than 0.10 ppm are the common sources of interference. Each, when present in the concentration indicated, will give a yellow color with ortho-tolidine and thus indicate a chlorine residual where actually none may exist.

Reagents: Ortho-tolidine - Dissolve 1.35 gm ortho-tolidine dihydrochloride in 500 ml distilled water. Add this solution, with constant stirring, to 500 ml dilute hydrochloric acid made by mixing 350 ml distilled water and 150 ml concentrated hydrochloric acid, (sp. gr. 1.18-1.19). Store in the dark.

Simple Ortho-Tolidine Test: The following procedures are for the Wallace and Tiernan Comparator. Directions for other makes of equipment are similar and are supplied by the manufacturer.

1. Rinse both cells with the water to be tested and fill to the mark. (Keep cells clean and free from dust).

2. Add one ml ortho-tolidine to one and mix.

3. Place both cells in the comparator in proper position. (The one with OT on the left).

4. Rotate disc until colors match and read residual in ppm.

Free chlorine "flashes" and the residual can be read immediately. A five minute wait is required before reading chloramine residuals.

Electronic pH Measurement.

pH is a way of expressing the hydrogen-ion concentration in a solution. In other words, pH is a measurement of the intensity of the acid or alkaline condition of the water.

Procedure:

1. Standardize the electronic pH meter by the use of pH 7 buffer solution. Wipe the electrodes dry with tissue paper and immerse them in the buffer solution. Check the temperature of the solution and set the temperature control (on manual) to this temperature. Place the electrodes on "Read" and adjust the meter to read 7.0 by use of the assymetry control. (Note: Standardize once daily.)

2. After standardization, rinse electrodes thoroughly and wipe dry prior to determining the pH of a sample.

3. For precise pH measurements, the sample temperature should be set on the temperature adjustment control. For most measurement, this will not be necessary, however.

4. Place the electrodes in the sample, place electrodes on "Read", and note the pH on the meter.

Note: Electrodes should always be placed on "Standby" when not immersed.

Color Measurements (Hellige).

Color in water is caused by organic and inorganic substances in solution. A Hellige Aqua Tester is available which is equipped with special calibrated glass color discs.

Procedure:

1. Place the color disc with the proper range (0 to 50 or 5 to 100 units) in the Aqua Tester.

2. Fill the left sight tube (the blank) with distilled water, and the right tube with sample.

3. Rotate the color disc until the left side of the viewing glass matches the color of the right side.

4. Read the corresponding color units from the disc.

Turbidity Measurement (Hellige).

Turbidity in water is caused by extremely small particles of suspended matter such as silt, organics, and organisms. Recording turbidimeters measure the effluent turbidities from each set of separation beds. If a turbidity check is required on any other stream, the Hellige turbidimeter can be used. Note: Due to different calibration standards, the units of turbidity are different for the two instruments.

Procedure:

1. Two turbidimeter tubes (50 mm and 20 mm viewing depths) are available. The 20 mm tube is used only with high turbidities (up to 150). Select the proper tube, make sure it is perfectly clean and free of finger prints, and fill to the line with sample.

2. Two adjustments are available to select the proper turbidity range. Filter discs (dark, light, and none) are located between the light source and the sample. A mirror, which may be opened or closed, is located on the door opposite the sample.

3. To obtain the turbidity, look through the eye sight with the light on, and note the white dot appearing at the bottom of the turbidimeter tubes with the calibration dial at zero. Rotate this dial until the white dot darkens and exactly blends with the surrounding background. Read the turbidity (ppm SiO_2) corresponding to the dial reading from the appropriate calibration curve.

Note: Make sure the light source is turned off when you are through. Each bulb must be individually calibrated, and thus they are very expensive!

Specific Conductance.

Specific conductance measures the ability of a water to convey an electric current. This property is usually used as an indication of the concentration of inorganic ions in the water.

Procedure:

1. A "Solu Bridge" conductance meter is available for specific conductance measurements. Turn the meter on and let it warm up for 5 minutes.

2. Check the temperature of the water and set this temperature on the temperature control.

3. Immerse the probe in the sample up to the line on the probe.

4. Adjust the conductance dial until the edges of the green zone in the electron-ray "magic eye" tube are well defined.

5. Read the specific conductance in micromhos/cm from the dial and record with the temperature. As specific conductance is usually recorded at 25°C, the correction curve (Figure T-2) can be used to mathematically adjust the specific conductance to standard conditions.

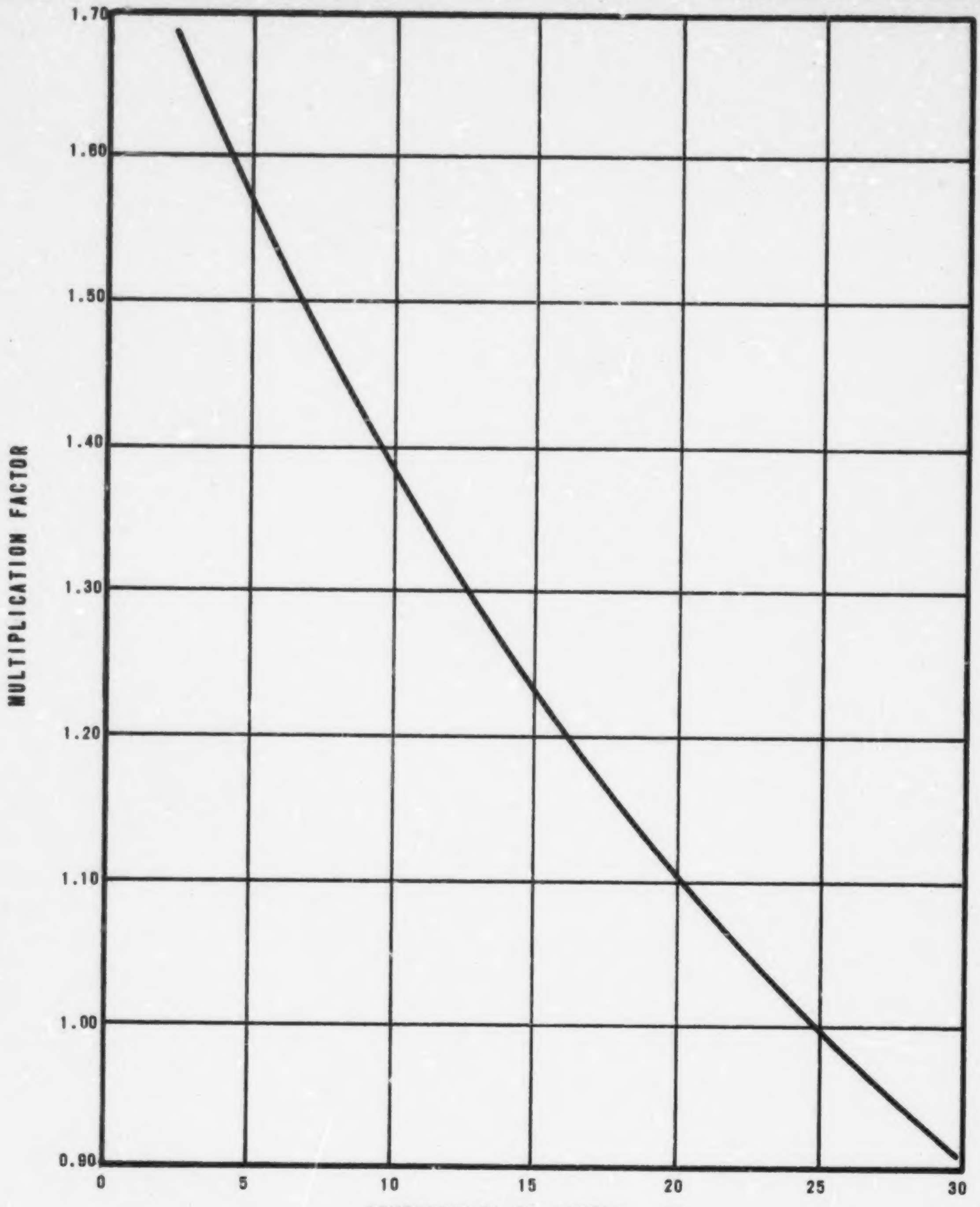


FIGURE T-2

FACTORS FOR CONVERTING SPECIFIC CONDUCTANCE OF WATER TO EQUIVALENT VALUES AT 25°C (BASED ON 0.01M KCl SOLUTION)

TESTS FOR PLANT EFFICIENCY AND RECORD PURPOSES

Total Phosphorus - (FWPCA Method).

1. Add 1 ml of sulfuric acid solution to 50 ml (or a smaller sample diluted to 50 ml) of sample in a 250 ml Erlenmeyer flask.

2. Add 0.4 grams of potassium persulfate.

3. Boil gently for 30 minutes.

4. Cool and transfer the sample to a 50 ml graduated cylinder and dilute to 50 ml with distilled water.

5. Add 2 ml of ammonium molybdate solution and mix.

6. Add 3 drops of stannous chloride solution and mix.

7. After 10 minutes standing for development of color, fill the spectrophotometer cells and determine the transmittance at a wavelength of 690 mµ against a distilled water blank.

8. Read mg P from the standard curve.

9. Calculate the concentration

$$\text{mg/l total P} = \frac{\text{mg P} \times 1000}{\text{ml sample}}$$

Orthophosphate - (Stannous Chloride Method).

Procedure.

1. Place 50 ml of sample or a suitable aliquot diluted to 50 ml in a 250 ml Erlenmeyer flask.

2. Add 1 drop phenolphthalein.

3. If sample turns pink, add strong acid solution dropwise to discharge the color.

4. Add 2.0 ml ammonium molybdate solution and mix thoroughly.

5. Add 0.15 ml (3 drops) stannous chloride reagent and mix thoroughly.

6. Prepare a distilled water blank to which all of the reagents have been added.

7. After 10 minutes but before 12 minutes, measure the transmittance at 690 mμ against the distilled water blank.

8. Read mg P from the standard curve.

9. Calculate the concentration

$$\text{mg/l P} = \frac{\text{mg P} \times 1000}{\text{ml sample}}$$

Total Phosphorus and Orthophosphate Reagents.

Sulfuric Acid Solution - Add 310 mls concentrated sulfuric acid to 600 ml distilled water, then dilute to 1 liter.

Ammonium Molybdate Solution - Dissolve 25.0 grams $(NH_4)_6Mo_7O_{24}.4H_2O$ in 175 ml distilled water. Add 77.5 ml concentrated sulfuric acid to 400 ml distilled water. Cool, add molybdate solution, and dilute to 1 liter.

Stannous Chloride Solution - Dissolve 2.5 grams fresh $SnCl_2.2H_2O$ in 100 ml of glycerol heated on a water bath.

Ammonia Nitrogen - Distillation Method.

1. Add 500 ml of distilled water and 10 ml phosphate buffer to flask and steam out still. Steam until free of ammonia.

2. Just before sample preparation, drain off excess water.

3. Place 100-400 ml of sample in Kjeldahl flask.

4. Neutralize to pH 7 if sample is acid or alkaline.

5. Add 25 ml phosphate buffer solution. See Standard Methods for calcium greater than 250 mg/l.

6. Dilute sample to 400 ml.

7. Distill approximately 200 ml of sample into 100 ml of boric acid solution. The tip of the condenser must extend below the boric acid.

8. Remove condenser from boric acid and allow distillation to continue for 2 or 3 minutes.

9. Measure volume of boric acid-distilled ammonia solution.

10. Place 10 to 50 ml of the boric acid-distilled ammonia in a 50-ml volumetric flask and dilute to mark with distilled water.

11. Add 2 ml of Nessler reagent.

12. Read the percent transmittance with the spectrophotometer at 445 mμ.

13. Prepare a blank with 2 ml Nessler reagent in 50 ml of distilled water.

14. $$\text{mg/l ammonia N} = \frac{(\text{mg N}) \times (\text{volume distillate ml}) \times (1000)}{(\text{sample volume ml}) \times (\text{ml distillate Nesslerized})}$$

Reagents:

Phosphate Buffer; pH 7.4 - Dissolve 14.3 grams potassium dihydrogen phosphate, KH_2PO_4, and 68.8 grams dipotassium hydrogen phosphate K_2HPO_4 and dilute to 1 liter with distilled water.

Boric Acid Solution - Dissolve 20 grams boric acid and dilute to 1 liter with distilled water.

Nessler Reagent - Dissolve 100 grams mercuric iodide and 70 grams potassium iodide in a small quantity of distilled water and add this mixture slowly, with stirring, to a cool solution of 160 grams NaOH in 500 ml distilled water. Dilute to 1 liter with distilled water. (CAUTION: TOXIC; take care to avoid ingestion)

SOUTH TAHOE PUBLIC UTILITY DISTRICT

AMMONIA NITROGEN - LAB ANALYSIS

		D	B	C		A	
Date	Identification	Sample Vol. l	ml Total Distillate	ml Distillate for Nessler	% T	mg N	mg/l NH_3 - N = $\frac{A}{D} \times \frac{B}{C}$

Organic Nitrogen.

1. Boil or distill off free ammonia as under Ammonia Nitrogen - Distillation Method.

2. Add 50 ml acid - sulfate solution.

3. Digest sample by boiling for 20 minutes after solution has become clear. Note: Most of the water has been evaporated when this color change is observed.

4. Cool the residue.

5. Add 300 ml distilled water.

6. Add 0.5 ml phenolphthalein and mix.

7. Carefully add 50 ml hydroxide - thiosulfate solution to the sample. Tilt the flask and carefully add reagent so that an alkaline layer forms at the bottom of the flask.

8. Connect flask to the steamed out condenser. Shake the flask to insure complete mixing. If a red phenolphthalein color fails to appear, add more reagent as above.

9. Distill and collect 200 ml of distillate below 50 ml boric acid.

10. Titrate with 0.02 N H_2SO_4.

11. Perform blank using all reagents and apply correction.

m 12. $$\text{mg/l Organic N} = \frac{(\text{ml } H_2SO_4 \text{ sample} - \text{ml } H_2SO_4 \text{ blank}) \times 280 \text{ as N}}{\text{ml sample}}$$

Organic Nitrogen Reagents:

Acid Sulfate Solution - Dissolve 267 grams K_2SO_4 in 1300 ml distilled water and add 400 ml concentrated H_2SO_4. Add 50 ml mercuric sulfate solution and dilute to 2 liters.

Mercuric Sulfate Solution - Dissolve 8 grams red HgO in 50 ml 1 + 5 H_2SO_4 and dilute to 100 ml with distilled water.

Hydroxide-Thiosulfate Solution - Dissolve 500 grams NaOH and 25 grams $Na_2S_2O_3 \cdot 5H_2O$ in distilled water and dilute to 1 liter.

.02 N H_2SO_4 - Dilute 28 ml concentrated H_2SO_4 to 1 liter. Dilute 20 ml of this solution to 1 liter.

Nitrate Nitrogen - (Brucine Method).

1. Place 2.00 ml of sample (containing 10 mg/l or less NO_3 as N) in a 50 ml beaker. Use only 50 ml beakers.

2. Add 1.0 ml brucine-sulfanilic acid to the sample. Use a safety pipette.

3. Place 10 ml H_2SO_4 reagent in another 50 ml beaker.

4. Carefully mix the contents of the two beakers together by adding the brucine solution to the acid. Pour from one beaker to the other four to six times.

5. Allow the sample to develop in the dark for 10 minutes ± minute.

6. Place 10 ml distilled water in the other beaker.

7. After 10 minutes, add the water to the sample, mix as before, and allow to cool in the dark for 25 minutes.

8. Prepare a distilled water blank in the same manner.

9. Measure the absorbance at 410 mμ against the distilled water blank.

10. Determine the amount of (NO_3 - N) from the standard curve.

11. (NO_3 - N) conc. mg/l = mg (NO_3 - N) x (500).

Nitrate - Nitrogen Reagents:

Brucine - Sulfanilic Acid - Dissolve 1 gram brucine sulfate and 0.1 gram sulfanilic acid in 70 ml hot distilled water. Add 3 ml concentrated HCl, cool, and dilute to 100 ml.

Sulfuric Acid Solution - Add 500 ml concentrated H_2SO_4 to 75 ml distilled water.

SOUTH TAHOE PUBLIC UTILITY DISTRICT

NITRATE NITROGEN - LAB ANALYSIS

Date	Identification	Dilution	% T	μg (NO_3 - N)	mg/l (NO_3 - N)

Methylene Blue Active Substance (MBAS). (Short Method)

1. Pour samples into appropriate separatory funnels. (To determine size of sample, see table below).

2. Add 1.0 ml of 5 N sulfuric acid and 5.0 ml of methylene blue - sulfuric acid solution to each sample.

3. Prepare a 100 ml distilled water blank in which the above reagents are included.

4. Add 10 ml of chloroform to each separatory funnel.

5. Invert and shake the samples once each second for 25 seconds. Allow the phases to separate.

6. Draw off the chloroform and filter through a plug of glass wool (previously wet with chloroform) into a 50 ml volumetric flask.

7. Repeat steps 4, 5 and 6 twice more adding the drawn off chloroform to the same flasks.

8. Rinse the glass wool plugs with chloroform into the 50 ml flasks and dilute to 50 ml with chloroform.

9. Determine the absorbance of the distilled water blank and samples in the spectrophotometer using a chloroform blank to zero the meter.

10. Subtract the distilled water blank reading from the reading for each sample and determine the weight of MBAS (mg) in the sample from the standard curve.

11. MBAS concentration (mg/l ABS) = $\dfrac{\text{weight of MBAS} \times 1000}{\text{sample volume (ml)}}$

Expected MBAS (mg/l ABS)	Sample Size (ml)	Separatory Funnel Size (ml)
0.025 - 0.5	400	500
0.1 - 2.0	100	250
0.5 - 10	20	250
2.5 - 50	4.0	250
5.0 -100	2.0	250

Note: Samples of less than 100 ml should be diluted to 100 ml with distilled water.

ABS Reagents:

5 N H_2SO_4 - Dilute 139 ml concentrated H_2SO_4 to 1 liter, adding acid to water first.

Methylene Blue Reagent, Concentrated - Dissolve 20 grams methylene blue in 1 liter distilled water.

Methylene Blue-Sulfuric Acid Solution - Dilute 2.0 ml 5 N H_2SO_4 and 17.5 ml concentrated Methylene Blue Reagent to 1 liter.

SOUTH TAHOE P. U. D.

ABS ANALYSIS

Date	Description	ml Sample	Absorbance	mg ABS	mg/l ABS

DATA SUMMARY SHEET FORM

Date: ____________________ Sampling Points: ______________

Day: ____________________ Type of Sample: ______________

Name of Test and Unit of Measurement	Results	Comments
Settleable Solids ml/l		
Suspended Solids mg/l		
Dissolved Solids mg/l		
Total Solids mg/l		
B.O.D. mg/l		
C.O.D. mg/l		
T.O.C. mg/l		
M.B.A.S. mg/l A.B.S.		
Ammonia Nitrogen mg/l N		
Nitrate mg/l N		
Total Nitrogen mg/l N		
Phosphate (ortho) mg/l P		
Total Phosphorus mg/l P		
Calcium mg/l Ca		
Magnesium mg/l		
Total Hardness (mg/l as $CaCO_3$)		
Alkalinity (mg/l as $CaCO_3$)		
Specific Conductance - Micromhos/cm		
Coliforms MPN		
Turbidity, turbidity units		
pH, pH units		
Color, units		
Temperature, °C		